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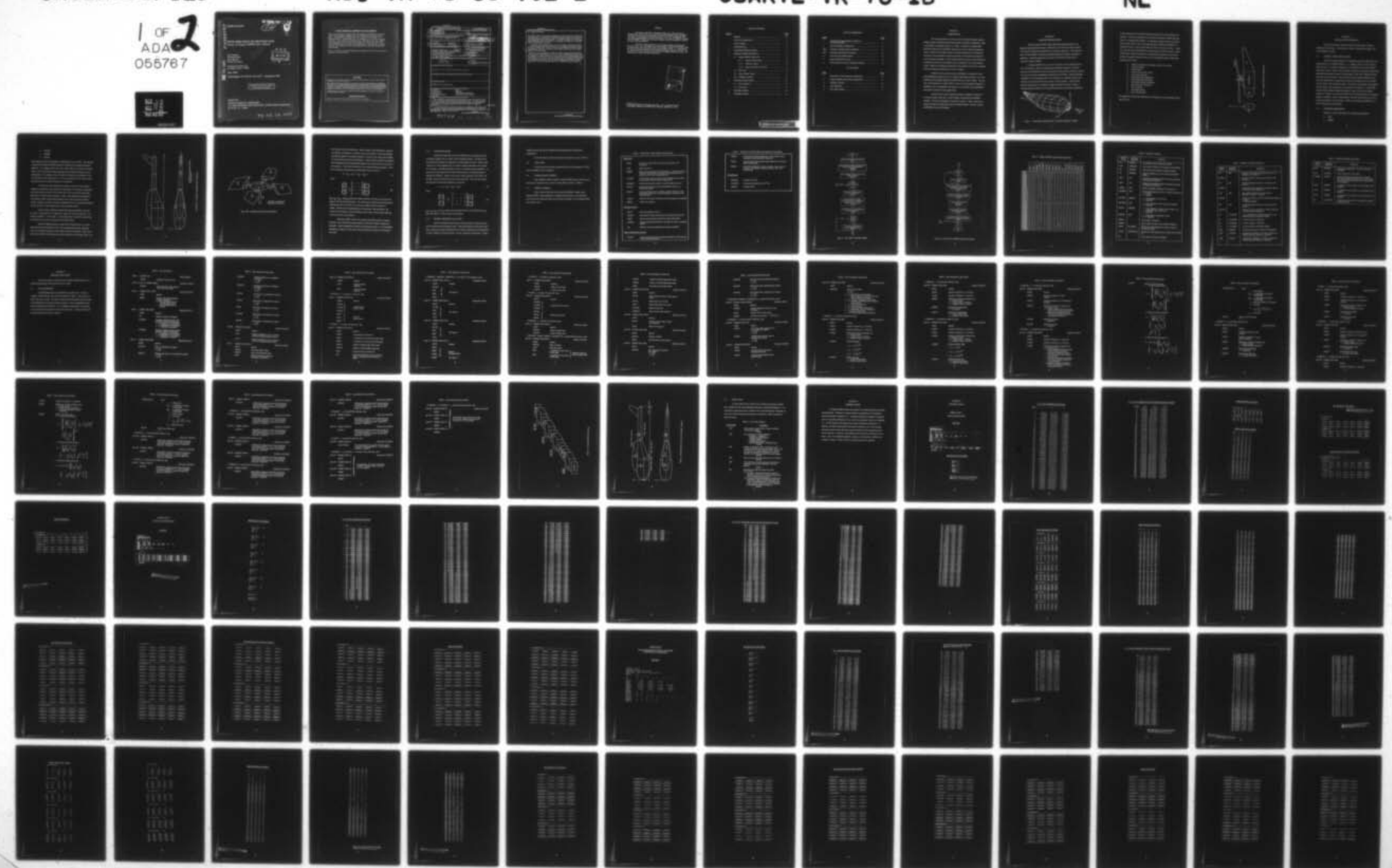

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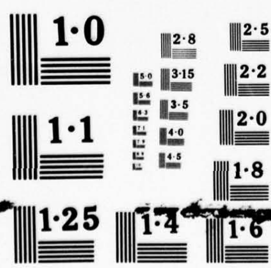


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# ROTOR WAKE EFFECTS ON HUB/PYLON FLOW
## Volume II, Program SHAPES User's Manual

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May 1978

Final Report for Period June 1975 - September 1977

Approved for public release;
distribution unlimited.

Prepared for

APPLIED TECHNOLOGY LABORATORY
U. S. ARMY RESEARCH AND TECHNOLOGY LABORATORIES (AVRADCOM)
Fort Eustis, Va. 23604

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## APPLIED TECHNOLOGY LABORATORY POSITION STATEMENT

This report presents a method for determining aerodynamic characteristics of helicopter shapes under the influence of the main rotor wake. The method is condidered to be worthy of publication for dissemination of information and the stimulation of further related research. The reader is cautioned that this method does not predict flow separation as the title would imply, nor does the rotor wake fully impinge upon the body of the helicopter. The method is useful, however, as a design tool in determining rotor-fuselage aerodynamic interference.

Mr. F. A. Raitch of the Aeromechanics Technical Area served as project engineer for this effort.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)


An investigation has been conducted to demonstrate the use of the Green's function method to study rotor wake effects on helicopter hub/pylon flow. This report consists of two volumes which document the theoretical formulation and the use of the digital computer program SHAPES (Subsonic Helicopter Aerodynamics Program with Effects of Separation). OVER

Volume I presents the theoretical formulation and corresponding numerical procedure for the study of incompressible potential aerodynamics with separated flow. While the


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20. Abstract (Continued)

formulation is valid for fully unsteady aerodynamics, this report is mainly concerned with rotor aerodynamics. A potential flow aerodynamic program, SHAPES, with suitable rotor wake representation was developed to predict the separation characteristics of arbitrary three-dimensional helicopter configurations. In particular, the effect of the rotor blade wake, blade shank wake, and hub wake in the separation of the flow over a lifting helicopter in forward flight is analyzed.

The present method has potential application in the design of helicopters because it provides an analytical capability which can be used to develop low-drag profile as well as to explore problem areas. Extensive numerical results obtained from Program SHAPES demonstrated the flexibility and accuracy of the method. These results are in excellent agreement with existing data.

Volume II, The User's Manual, describes the structure and use of Program SHAPES. SHAPES is written in FORTRAN IV for operation on the CDC 6600 digital computer system at the Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, VA. The User's Manual (Volume II) contains detailed information for preparing an input data deck and interpreting the computed data; a discussion of various subroutines, flow charts, common storage and definition of FORTRAN variables; sample cases to illustrate the program output; and a FORTRAN listing of the program.


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# PREFACE

This report, prepared by Aerospace Systems, Inc. (ASI), Burlington, Massachusetts, for the U.S. Army under Contract DAAJ02-75-C-0041, documents the results of research performed during the period June 1975 to September 1977. The study was sponsored by the Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory,* Fort Eustis, Virginia, with Mr. Frederick A. Raitch serving as Technical Monitor.

The effort was directed by Mr. John Zvara, President and Technical Director of ASI. Mr. Paul Soohoo served as Principal Technical Staff Member under the supervision of Mr. Richard B. Noll, Vice President of ASI. Dr. Luigi Morino, Director of Computational Continuum-Mechanics Program at Boston University, and Dr. Norman D. Ham, Director of the V/STOL Technology Laboratory at MIT, contributed to the study as Principal Consultants.



*Redesignated Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM), effective September 1, 1977.

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## SECTION 1

## INTRODUCTION

This volume describes the structure and use of a digital computer program, SHAPES, Subsonic Helicopter Aerodynamic Program with Effects of Separation, which was developed by Aerospace Systems, Inc. (ASI), to analyze the incompressible potential aerodynamics of helicopter configuration with rotor wakes and separation effects. Volume I of this report contains a complete description of the theoretical formulation and corresponding numerical procedure for the aerodynamic method for use in the computer program. It also includes extensive numerical results showing the flexibility and accuracy of the method as well as comparison with several existing results. Proper use of SHAPES is predicated on the assumption that the user is familiar with the techniques and limitations set forth in Volume I.

SHAPES is written almost entirely in FORTRAN IV for operation on the CDC 6600 digital computer system at the Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, Virginia. The program was developed with a highly modular structure for ease of program checkout, to simplify the user's understanding of the program, and to facilitate any modifications that might be required for future applications.

Sections 2 and 3 contain programming details of SHAPES: functions of the various routines, flow charts, common storage, and definition of FORTRAN variables. The use of the program is presented in Section 4. Sample cases are presented in Section 5 to illustrate the output of Program SHAPES. Section 6 contains the FORTRAN listing of the program.

## SECTION 2

## COMPUTER PROGRAM SHAPES

Computer program SOUSSA (Steady Oscillatory Unsteady Subsonic and Supersonic Aerodynamics) discussed in Subsection 2.2 of Volume I has been modified to include rotor dynamics and separation from hub/pylon components. The revised program is called SHAPES, for Subsonic Helicopter Aerodynamic Program with Effects of Separation. Geometry preprocessor for single-rotor helicopter configurations is included in Program SHAPES.

In Program SHAPES the user need not be familiar with the aerodynamic portion of the program, unlike other sophisticated aerodynamic programs in which the choice for the combination of various aerodynamic functions (sources, doublets, vortices) is an art which requires considerable understanding of the method. Another advantage of SHAPES is that the paneling used for the aerodynamics is completely arbitrary and, therefore, may coincide with the one used for structural analysis. A typical finite element representation of a helicopter fuselage configuration is shown in Figure 1. The aerodynamic paneling can be accomplished manually by inputting the coordinates

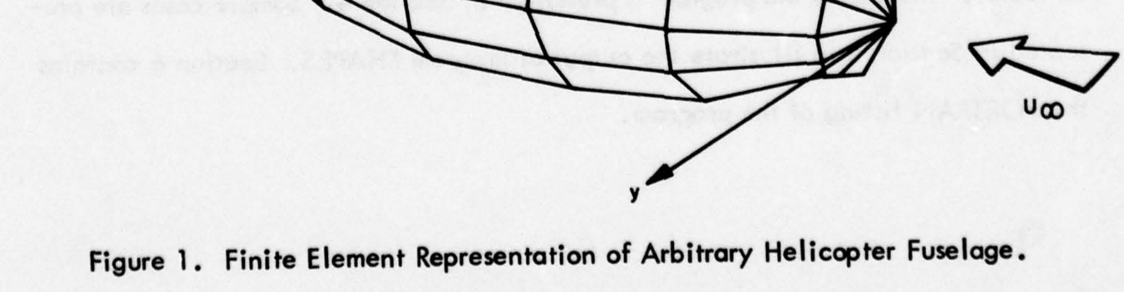



Figure 1. Finite Element Representation of Arbitrary Helicopter Fuselage.

of the corner points of all selected aerodynamic panels or by using a geometry preprocessor. A geometry preprocessor for conventional helicopter configurations (see Figure 2) is incorporated in SHAPES. The fuselage is assumed to have an elliptical center section with the nose and tail approximated by elliptical paraboloids. An ellipsoidal element is used to approximate the rotor hub and pylon sections. In addition, the rotor shaft and blade shank are represented by cylindrical sections. Given the helicopter configuration geometry, the preprocessor computes the corner point locations of required aerodynamic panels for the complete helicopter configuration. Required inputs include:

- Shape and dimensions of fuselage, pylon, shaft, and hub
- Number of blades
- Rotor diameter
- Extent of root cutout or shank
- Cross-section of shank
- Rotor blade airfoil designation
- Rotor blade chord distribution
- Rotor blade thickness distribution
- Rotor blade twist distribution
- Rotor tip speed
- Freestream velocity
- Rotor wake geometry

This capability eliminates the requirement for the selection of the aerodynamic paneling by the user.

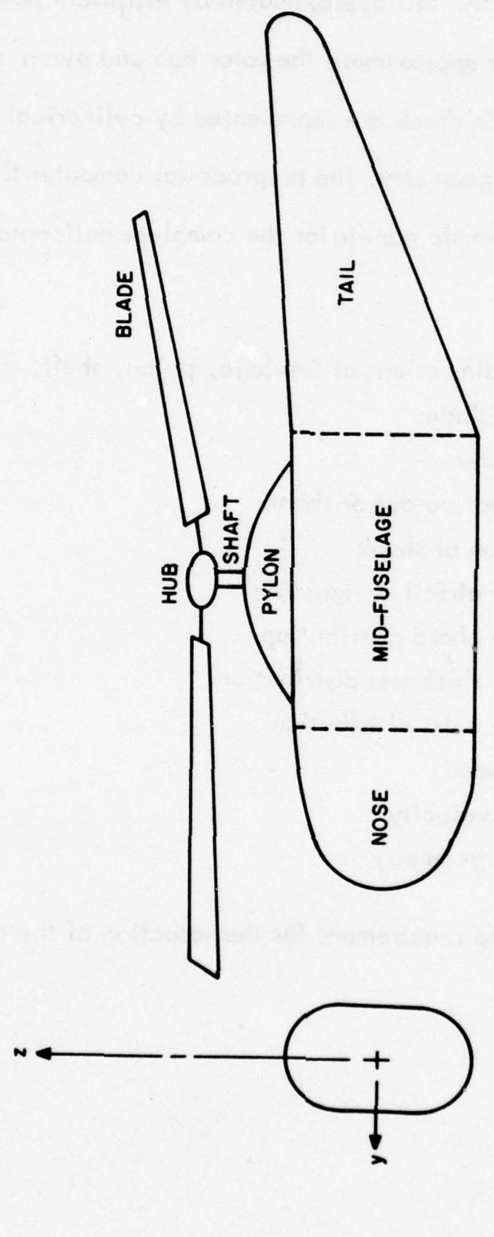



Figure 2. Typical Helicopter Configuration.

## SECTION 3

## PROGRAM SHAPES DESCRIPTION

This section contains a brief description of the organization of Program SHAPES and its subroutines, a flow diagram, a table of common block storage, and a list of FORTRAN variables.

### 3.1 PROGRAM SHAPES ORGANIZATION

The present computer program for incompressible potential aerodynamics with separated flow for a complete helicopter, i.e., fuselage, pylon, and rotor, contains three main parts: (1) geometric preprocessor, (2) coefficient matrix, and (3) pressure distribution and force. Based on data provided, the geometric preprocessor automatically generates the aerodynamic panels for the helicopter as well as the numbering and location of the panel corner points in the reference Cartesian (global) coordinate system. The matrix coefficients are determined by evaluating the doublet and source integrals over the surface of the aerodynamic panels. This yields N simultaneous linear equations with N unknown velocity potentials at the centroids of N elements. A standard IBM subroutine GELG (Gaussian elimination method) is used to solve for the unknown potentials. To obtain a continuous distribution for the velocity potential, an averaging scheme is introduced. Hence, the perturbation velocities and the pressure at the centroid of each element can be evaluated. Finally, the aerodynamic coefficients, i.e., lift and induced drag, are computed.

#### 3.1.1 GEOMETRIC PREPROCESSOR

Presently, five main subroutines form the geometric preprocessor:

- DATA
- PREPRO

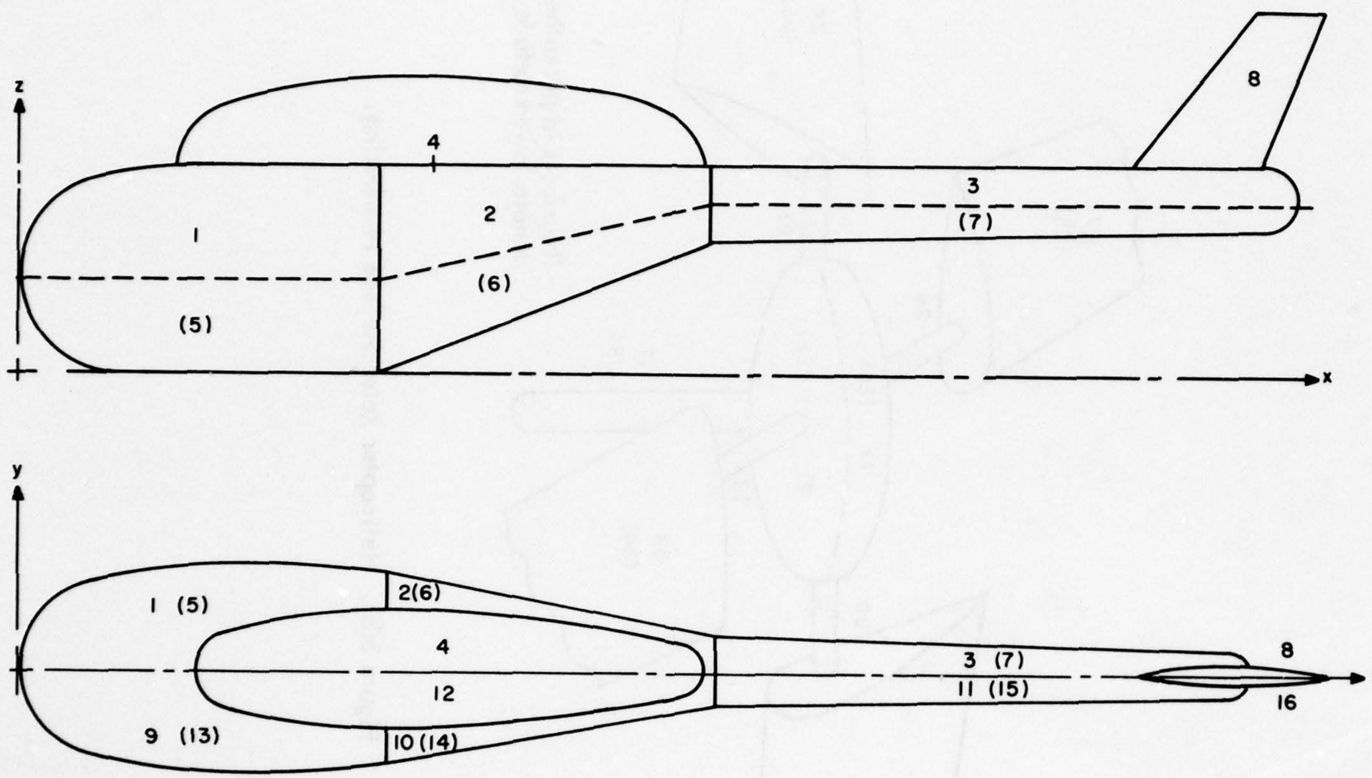
- COODPT
- GEOMET
- VEC123

Basic geometric inputs of the problem are defined by the user in DATA. This subroutine automatically generates the global subsurface numbering of the complete helicopter geometry; i.e., fuselage, pylon, shaft, hub, shank, blade, and vertical tail sections. Figure 3 shows the subsurface global numbering for the helicopter fuselage and rotor configurations. One important input for DATA is the number of the elements in the x and y directions for each subsurface, IS. This input controls the total number of aerodynamic panels used to model the geometry of the problem.

The variation of the element sizes (uniform or nonuniform finite element breakup) is another basic input parameter to the program. In the present investigation, particular attention must be paid to the flow field in the vicinity of the rotor shaft, pylon, hub, and upper fuselage elements. Hence, small elements are prescribed for the hub/pylon region, whereas larger elements can be used on the lower fuselage section. Moreover, the local curvilinear coordinates $\xi$ and $\eta$ are automatically defined so that the normal to each surface panel is always directed outward.

Finally, DATA automatically defines the parameter KWAKES, which has the value 1 if the subsurface, IS, generates a wake and a value of 0 otherwise. For example, KWAKES = 1 on the pylon. A vortex-layer wake is assumed to emanate from the separation point and this is represented as a doublet layer.

Subroutine PREPRO generates a nodal function NOFCT (IXY, IS), which relates the local nodal numbering, IXY, with the required global nodal numbering. Next, the Cartesian coordinates of these nodes is obtained by COODPT. Basic inputs required for COODPT are the shape and overall dimensions of the fuselage, pylon, and




(Numbers in parentheses denote lower surface.)

Figure 3(a). Helicopter Fuselage Surface Numbering.

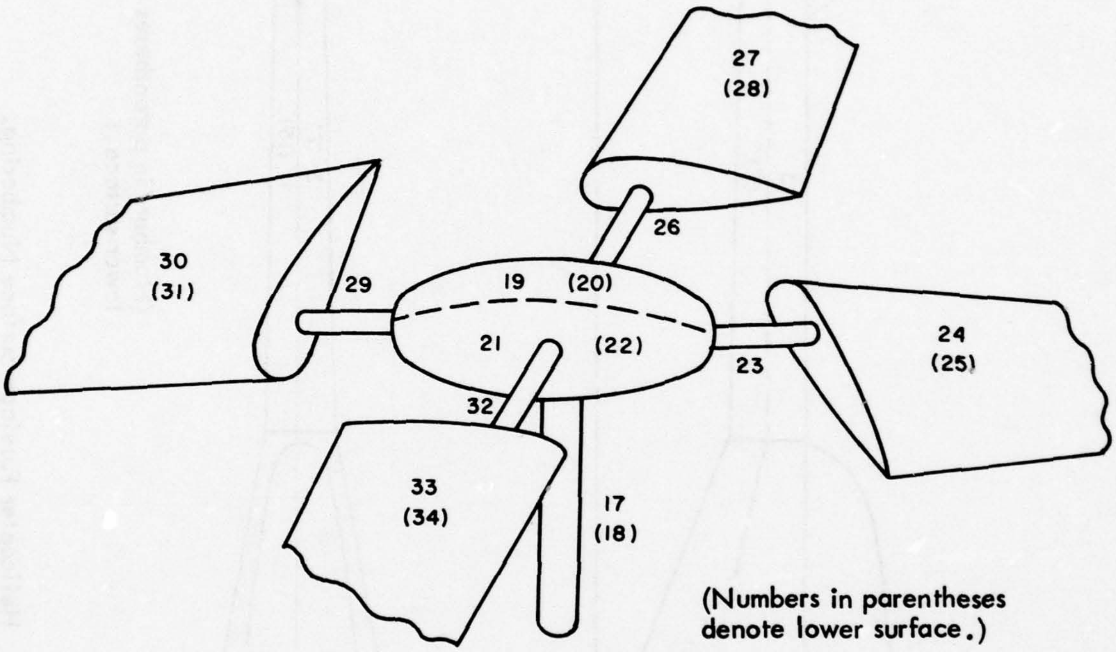



Figure 3(b). Helicopter Rotor Surface Numbering.

hub sections, blade-twist distribution, blade thickness, chord distribution, number of rotor blades, rotor diameter, and extent of root cutout (shank). Subroutine GEOMET automatically generates a parameter NODE as a function of the corner point ICORNR for each aerodynamic panel of the helicopter. Finally, VEC123 completes the geometry of the aerodynamic panel (hyperboloidal element) that contains the four corner points of the element. This results in continuity of the complete helicopter geometry. Note that the equation that represents a hyperboloidal element is given by

$$\overline{P} = \overline{P}_0 + \overline{P}_1 \xi + \overline{P}_2 \eta + \overline{P}_3 \xi \eta \qquad (1)$$

where

$$\begin{Bmatrix} \overline{P}_0 \\ \overline{P}_1 \\ \overline{P}_2 \\ \overline{P}_3 \end{Bmatrix} = \frac{1}{4} \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & 1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix} \begin{Bmatrix} \overline{P}_{pp} \\ \overline{P}_{pm} \\ \overline{P}_{mp} \\ \overline{P}_{mm} \end{Bmatrix} \qquad (2)$$

$\overline{P}_{pp}$, $\overline{P}_{pm}$, $\overline{P}_{mp}$, and $\overline{P}_{mm}$ denote the Cartesian location of the four corner points and $\overline{P}_0$ gives the centroid of the element. This subroutine also performs the Prandtl-Glauert transformation and the rotation of the axis due to angle of attack and angle of sideslip. PRINTA writes the specifications of the problem, node coordinates, the centroid of each element, nodal numbering for each surface, and the nodal numbering of the corner points of the element.

Subroutine CHECK verifies if the maximum permissible number of elements along the x and y directions on each subsurface and the total number of elements are exceeded. Several compatibility conditions exist between the data. If an incompatible relationship is present, an error code will be printed and the execution of the program terminated.

### 3.1.2 COEFFICIENT MATRIX

Subroutine COEFF forms the matrix coefficients by evaluating the source and doublet integrals over the surface of the aerodynamic panels. The effect of the rotor wake and the presence of separation are automatically included. COEFF yields a system of N linear equations with N unknown velocity potentials at the centroid of N elements. SOLUTN calls GELG to solve N simultaneous linear equations. To obtain the velocity potential at the node of each element, an averaging scheme is employed by AVERAG. Using the value of the velocity potential at the nodes, PHI provides a continuous distribution of the velocity potential. Note that the equation that represents this continuous distribution is given by

$$\varphi = \varphi_0 + \varphi_1 \xi + \varphi_2 \eta + \varphi_3 \xi \eta \tag{3}$$

where

$$\begin{Bmatrix} \varphi_0 \\ \varphi_1 \\ \varphi_2 \\ \varphi_3 \end{Bmatrix} = \frac{1}{4} \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & 1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix} \begin{Bmatrix} \varphi_{pp} \\ \varphi_{pm} \\ \varphi_{mp} \\ \varphi_{mm} \end{Bmatrix} \tag{4}$$

$\varphi_{pp}$, $\varphi_{pm}$, $\varphi_{mp}$, and $\varphi_{mm}$ denote the velocity potential at the nodal points and $\varphi_0$ gives the value of $\varphi$ at the centroid of the element.

### 3.1.3 PRESSURE DISTRIBUTION AND FORCE

VELXYZ evaluates the perturbation velocity (Cartesian coordinate system) at the centroid of each aerodynamic panel. Subroutine CPLINR uses Bernoulli's equation to compute the pressure distribution at the centroid. PRINTB writes the distribution of sources, doublets, velocity potential, velocity, and pressure distribution. Finally,

FORCE evaluates the total lift coefficient and induced drag on the helicopter configuration.

A brief description of the main program and subroutines is given in Table 1.

## 3.2 FLOW CHART

In order to provide a general understanding of the overall program, the flow chart for SHAPES is shown in Figure 4.

## 3.3 COMMON BLOCK STORAGE

Most FORTRAN-related variables in Program SHAPES used by more than one subroutine are organized into a number of common blocks as shown in Table 2.

## 3.4 FORTRAN VARIABLES

Table 3 presents definitions of all principal FORTRAN variables used in Program SHAPES. Where appropriate, mathematical definitions are also indicated. The units of each variable are those used internally by SHAPES, and occasionally differ from the input units.

Table 1. Description of Main Program and Subroutines.

| | |
|---|---|
| **Preprocessor** | |
| MAIN | Controls the logical flow of information supplied by the subroutines. |
| DATA | Reads input data. |
| PREPRO | Defines nodal numbering for the helicopter. (The surface of the helicopter configuration is divided into 34 subsurfaces with a maximum of four rotor blades permitted.) |
| COODPT | Defines and/or reads in the Cartesian coordinates of the nodes on the surface of the helicopter configuration. |
| GEOMET | Defines the four nodal corners for each aerodynamic panel. |
| VEC123 | Defines the equation of each hyperboloidal surface (i.e., aerodynamic panel). |
| PRINTA | Writes specification of the problem, nodal numbering for the helicopter configuration, nodal coordinates, and the centroid of the elements. |
| CHECK | Verifies if the maximum defined in the main program is exceeded. |
| DEBUG | Writes error message. |
| **Coefficient Matrix** | |
| COEFF | Forms the coefficient matrix. |
| SOLUTN | Calls GELG to obtain the perturbation aerodynamic potential. |
| GELG | Solves system of general equations by Gauss elimination. |
| AVERAG | Obtains potential distribution at the nodes by using an averaging scheme. |
| PHI | Defines a continuous distribution of velocity potential. |
| **Pressure Distribution and Force** | |
| VELXYZ | Evaluates the velocity (perturbation) distribution at the centroid of each aerodynamic panel. |

Table 1. Description of Main Program and Subroutines (Concluded).

| | |
|---|---|
| CPLINR | Evaluates the pressure distribution at the centroid of each aerodynamic panel (Bernoulli's equation). |
| FORCE | Evaluates the lift and induced drag coefficients on the helicopter configuration. |
| PRINTB | Writes the distribution of source, doublet, wake, velocity potential, perturbation velocities, pressure, lift, and induced drag. |
| <u>Miscellaneous</u> | |
| ASINH(X) | Evaluates $\sinh^{-1}(X)$ . |
| ATANP(X) | Evaluates principal part of $\tan^{-1}(X)$ . |
| LOG(X) | Evaluates $\ln(X)$ . |

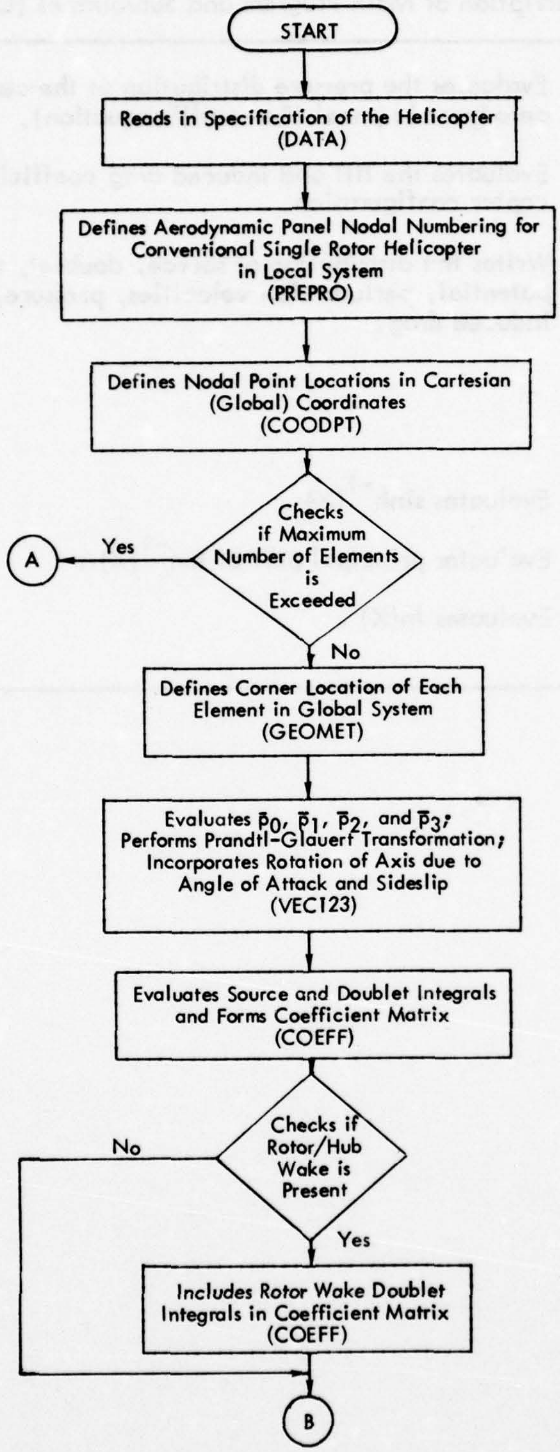



**Figure 4. Flow Chart for SHAPES Program.**

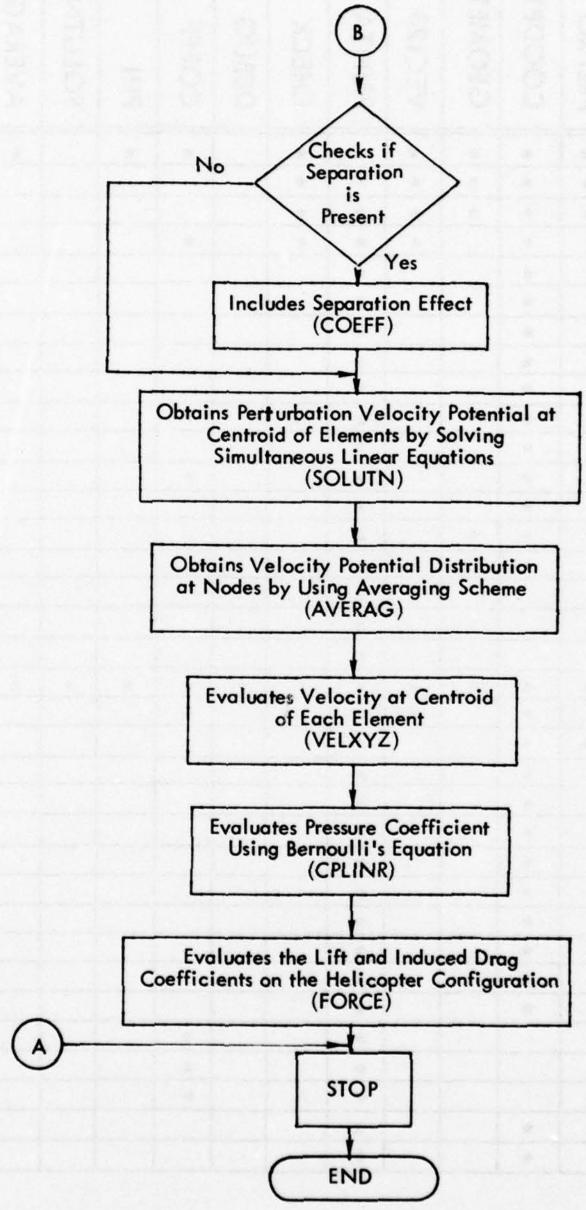



**Figure 4. Flow Chart for SHAPES Program (Concluded).**

Table 2. Program SHAPES Common Block Organization.

| | MAIN | DATA | PREPRO | COODPT | GEOMET | VEC123 | PRINTA | CHECK | DEBUG | COEFF | PHI | SOLUTN | AVERAG | VELXYZ | CPLINR | FORCE | PRINTB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ZZZ1 | * | * | * | * | * | * | * | * | | * | * | | * | * | * | * | * |
| ZZZ2 | * | * | * | * | * | * | * | * | | | | | | | | | * |
| ZZZ3 | * | * | * | * | * | * | * | * | | | | | | | | | * |
| ZZZ4 | * | * | | * | | * | * | * | | * | | | | | | * | * |
| ZZZ5 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ6 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ7 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ8 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ9 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ10 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ11 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ12 | * | * | | * | | | * | | | * | | | | | | | * |
| ZZZ13 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ14 | * | * | | * | * | | * | | | | | | | | | | * |
| ZZZ15 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ16 | * | * | | | | | * | | | | | | | | | | * |
| ZZZ17 | * | * | | | | | * | | | | | | | | | | * |
| ZZZ18 | * | * | | | | | * | | | | | | | | | | * |
| ZZZ19 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| ZZZ20 | * | * | | * | | * | * | | | * | | | | | | | * |
| ZZZ21 | * | * | * | * | | | * | | | | | | | | | | * |
| ZZZ22 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ23 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ24 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ25 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ26 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ27 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ28 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ29 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ30 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ31 | * | * | | | | | * | | | * | | | | | | | * |
| ZZZ32 | * | * | | | | | * | | | * | | | | | | | * |
| ZZZ33 | * | * | | | | | * | | | * | | | | | | | * |
| ZZZ34 | * | * | | * | | | * | | | | | | | | | | * |
| ZZZ35 | * | * | | * | | | * | | | | | | | | | | * |

Table 3. FORTRAN Variables.

| Variable Name | Maximum Dimension | Definition |
|---|---|---|
| AA | (NESQ) | A coefficient matrix (stored columnwise). |
| AVG | (NNODE) | The number of elements surrounding the node INODE. |
| BC | (NELEM) | Downwash on the centroid of IELEMth element. |
| CP | (NELEM) | Pressure coefficient at the centroid of the IELEMth element. |
| HCSI | (11) | Defines the normalized nodal line locations along the x direction for surface IS. |
| HETA | (11) | Defines the normalized nodal line locations along the y direction for surface IS. |
| ISFACE | (NS) | Defines the global numbering of the surface IS. |
| KNORML | (NS) | Indicates the direction of the unit normal on surface IS.<br>= 1 outward<br>=-1 inward |
| KROTOR | (NELEM) | = 1 if the element is on the rotor<br>= 0 otherwise |
| KROTORS | (NS) | = 1 if the subsurface is part of the rotor assembly<br>= 0 otherwise |
| KWAKE | (NELEM) | = 1 if the element is in contact with a wake, i.e., rotor blade, hub, pylon, etc.<br>= 0 otherwise |
| KWAKES | (NS) | = 1 if the surface IS generates a wake<br>= 0 if otherwise |
| NELEM | | Total number of elements. |
| NNODE | | Total number of nodes on the surfaces considered. |
| NODE | (4,NELEM) | Defines the nodal numbering at the four corners of the element IELEM. |
| NOFCT | (NXYMP,34) | Defines the nodal numbering of the nodes on the surface IS. |
| NS | | Total number of surfaces considered. |

Table 3. FORTRAN Variables (Continued).

| Variable Name | Maximum Dimension | Definition |
|---|---|---|
| NT | (34) | Subtotal of the number of elements up to, but not including, the surface IS. |
| NTMAX | | Maximum number of elements permissible on the helicopter. |
| NX | (34) | Number of elements along the x direction of the surface IS. |
| NXMAX | | Maximum number of elements permissible along the x direction on any subsurface. |
| NXY | (34) | Total number of elements on the surface IS [NXY(IS) = NX(IS) * NY(IS)] |
| NXYMP | | Defines the maximum number of elements permitted on a surface = NXMAX*NYMAX |
| NY | (34) | Number of elements along the y-direction of the surface IS. |
| NYMAX | | Maximum number of elements permissible along the y direction on any subsurface. |
| PC | (3,NELEM) | x,y,z coordinates of centroid of elements in the reference Cartesian coordinate system. |
| P1 | (3,NELEM) | A vector along the $\xi$ direction. |
| P2 | (3,NELEM) | A vector along the $\eta$ direction. |
| P3 | (3,NELEM) | A vector normal to the element IELEM. |
| PHIC | (NELEM) | Velocity potential at the center of the element. |
| PHI1 | (NELEM) | Interpolation coefficient - the local variation of velocity potential along the $\xi$ direction. |
| PHI2 | (NELEM) | Interpolation coefficient - the local variation of velocity potential along the $\eta$ direction. |

Table 3. FORTRAN Variables (Concluded).

| Variable Name | Maximum Dimension | Definition |
|---|---|---|
| PH13 | (NELEM) | Interpolation coefficient - the local variation of downwash. |
| SOR | (NNODE) | Velocity potential at the nodes. |
| SOURCE | (NELEM) | Source distributions at the centroids of elements. After calling subroutine GELG, this variable stores the velocity potential distributions at the centroids of the elements. |
| VELX | (NELEM) | x component of the velocity at the centroids of the elements. |
| VELY | (NELEM) | y component of the velocity at the centroids of the elements. |
| VELZ | (NELEM) | z component of the velocity at the centroids of the elements. |
| XK | (3,NNODE) | Coordinates of the nodes in the reference Cartesian coordinate system. |

# SECTION 4

# PROGRAM SHAPES USAGE

This section contains a description of the Program SHAPES data input including program options and a description of error codes.

## 4.1 INPUT DESCRIPTION

All SHAPES data input is accomplished via punched cards. The input variables, required formats, and options are presented in Table 4. Some inputs may require more than one card. The number of input data cards required varies from case to case depending on the type of problem considered. Several compatibility conditions exist among some of the data. If an incompatible relationship is encountered, an error code will be printed and the execution terminated. A typical data setup for running multiple cases is shown in Figure 5.

Table 4. Input Description.

| | | | |
|---|---|---|---|
| Data 1: | FORMAT (I5) | | (Main Program) |
| | NCASE | Number of cases to be run | |
| Data 2, 3, and 4: | FORMAT (20A4) | | (Subroutine DATA) |
| | GG(20) | Name, location, date, description of job, and remarks | |
| Data 5: | FORMAT (2A4, 10I5) | | (Subroutine DATA) |
| | GG(2) | Remarks | |
| | KREAD | Control code for the definition of nodal coordinates<br>= 0 the coordinates will be defined automatically<br>= 1 the coordinates will be read in | |
| Data 6: | FORMAT (2A4,10I5) | | (Subroutine DATA) |
| | GG(2) | Remarks | |
| | NS | Number of surfaces considered | |
| | KSYMMY | Symmetry condition between left- and right-hand side of helicopter<br>= -1 if geometry is antisymmetric<br>= 0 if geometry has no symmetry<br>= 1 if geometry is symmetric | |
| | KSYMMZ | Symmetry condition between upper and lower surfaces of helicopter<br>= -1 if geometry is antisymmetric<br>= 0 if geometry has no symmetry<br>= 1 if geometry is symmetric | |
| Data 7: | FORMAT (2A4,10I5) | | (Subroutine DATA) |
| | GG(2) | Remarks | |
| | NPYLON | Pylon is considered for analysis<br>= 1 yes<br>= 0 no | |
| | NBODY1 | Fuselage nose section is considered for analysis<br>= 1 yes<br>= 0 no | |

Table 4. Input Description (Continued).

| | | | |
|---|---|---|---|
| | NBODY2 | Fuselage midsection is considered for analysis<br>= 1 yes<br>= 0 no | |
| | NBODY3 | Fuselage tail section is considered for analysis<br>= 1 yes<br>= 0 no | |
| | NVTAIL | Vertical tail is considered for analysis<br>= 1 yes<br>= 0 no | |
| | NSHAFT | Rotor shaft is considered for analysis<br>= 1 yes<br>= 0 no | |
| | NHUB | Rotor hub is considered for analysis<br>= 1 yes<br>= 0 no | |
| | NSHANK | Blade shank is considered for analysis<br>= 1 yes<br>= 0 no | |
| | NBLADE | Rotor blade is considered for analysis<br>= 1 yes<br>= 0 no | |
| Data 8: | FORMAT (2A4,10I5) | | (Subroutine DATA) |
| | GG(2) | Remarks | |
| | KPYL1 | Number of elements in the x direction of the mid-fuselage before the pylon | |
| | KPYL2 | Number of elements in the x direction of the mid-fuselage after the pylon | |
| Data 9: | FORMAT (2A4,7F8.3) | | (Subroutine DATA) |
| | GG(2) | Remarks | |
| | UMACH | Freestream Mach number | |
| | OMEGA | Rotor rotational speed (rpm) | |
| | AREA | Reference area for evaluating aerodynamic coefficient | |

Table 4. Input Description (Continued).

Data 10: FORMAT (2A4,7F8.3) (Subroutine DATA)

| GG(2) | Remarks |
|---|---|
| ALFA | Angle of attack (degrees) |
| BETA | Angle of sideslip (degrees) |

If NPYLON = 1, use Data 11; otherwise, skip.

Data 11: FORMAT (2A4,7F8.3) (Subroutine DATA)

| GG(2) | Remarks |
|---|---|
| XPYCTR<br>YPYCTR<br>ZPYCTR | Coordinates of pylon's center |
| RXPYL<br>RYPYL<br>RZPYL | Radii of pylon section |

If NVTAIL = 1, use Data 12; otherwise, skip.

Data 12: FORMAT (2A4,7F8.3) (Subroutine DATA)

| GG(2) | Remarks |
|---|---|
| VSPAN | Span length of vertical tail |
| XLEZV | x coordinate of vertical tail leading edge |
| XTEZV | x coordinate of vertical tail trailing edge |
| TANLEV | Tangent of leading edge sweep angle |
| TANTEV | Tangent of trailing edge sweep angle |
| TAUV | Thickness ratio of vertical tail |
| ZPV | Height of root chord of vertical tail with respect to global Cartesian coordinate system |

Table 4. Input Description (Continued).

If (NBODY1 + NBODY2 + NBODY3) $\neq$ 0, use DATA 13-16; otherwise, skip.

Data 13: FORMAT (2A4, 7F8.3) (Subroutine DATA)

| GG(2) | Remarks |
|---|---|
| XNOSE<br>XBD1<br>XBD2<br>XTAIL | See Figure 6 |

Data 14: FORMAT (2A4,7F8.3) (Subroutine DATA)

| GG(2) | Remarks |
|---|---|
| YNOSE<br>YBD1<br>YBD2<br>YTAIL | See Figure 6 |

Data 15: FORMAT (2A4,7F8.3) (Subroutine DATA)

| GG(2) | Remarks |
|---|---|
| ZNOSE<br>ZBD1<br>ZBD2<br>ZTAIL | See Figure 6 |

Data 16: FORMAT (2A4,7F8.3) (Subroutine DATA)

| GG(2) | Remarks |
|---|---|
| RYBD1<br>RZBD1<br>RYBD2<br>RZBD2 | Radii of fuselage section<br>See Figure 6 |

Table 4. Input Description (Continued).

If NSHAFT = 1, use Data 17; otherwise, skip.

| | | | |
|---|---|---|---|
| Data 17: | FORMAT (2A4,7F8.3) | | (Subroutine DATA) |
| | GG(2) | Remarks | |
| | RSHAFT | Radius of rotor shaft | |
| | LSHAFT | Length of rotor shaft | |

If NHUB = 1, use Data 18; otherwise, skip.

| | | | |
|---|---|---|---|
| Data 18: | FORMAT (2A4,7F8.3) | | (Subroutine DATA) |
| | GG(2) | Remarks | |
| | XHUBCR<br>YHUBCR<br>ZHUBCR | Coordinates of hub center | |
| | RXHUB<br>RYHUB<br>RZHUB | Radii of hub section | |

If NSHANK = 1, use Data 19; otherwise, skip.

| | | | |
|---|---|---|---|
| Data 19: | FORMAT (2A4,7F8.3) | | (Subroutine DATA) |
| | GG(2) | Remarks | |
| | RSHANK | Radius of blade shank | |
| | LSHANK | Length of blade shank | |

If (NSHAFT + NHUB + NSHANK + NBLADE) $\neq 0$, use Data 20-23; otherwise, skip.

| | | | |
|---|---|---|---|
| Data 20: | FORMAT (2A4,7F8.3) | | (Subroutine DATA) |
| | GG(2) | Remarks | |
| | RROTOR | Blade tip radius | |
| | YCUT | Blade root cutout | |
| | XBLE | x coordinate of root chord leading edge | Reference blade at azimuth angle of 90° |
| | XBTE | x coordinate of root chord trailing edge | |

Table 4. Input Description (Continued).

| | | | |
|---|---|---|---|
| | TANBLE | Tangent of leading edge sweep angle | |
| | TANBTE | Tangent of trailing edge sweep angle | |
| | TAUBL | Thickness ratio of blade airfoil | |
| Data 21: | FORMAT (2A4,7F8.3) | | (Subroutine DATA) |
| | GG(2) | Remarks | |
| | THET75 | Blade collective pitch at three-quarter radius | |
| | THET1C | Blade lateral cyclic pitch | |
| | THET1S | Blade longitudinal cyclic pitch | |
| | CONING | Blade coning angle | |
| | AZIMUTH | Blade azimuth angle (degrees) | |
| Data 22: | FORMAT (2A4,7F8.3) | | (Subroutine DATA) |
| | GG(2) | Remarks | |
| | RPITCH | Collective pitch angle at blade root (degrees) | |
| | TWIST | Blade twist (degrees) | |
| Data 23: | FORMAT (2A4,10I5) | | (Subroutine DATA) |
| | GG(2) | Remarks | |
| | KBLADE | Number of blades | |
| | ITWIST | Defines blade twist distribution | |
| Data 24: | FORMAT (2A4,10I5) | | (Subroutine DATA) |
| | GG(2) | Remarks | |
| | NWAKPY | Flow separation considered for analysis<br>= 1 yes<br>= 0 no | |

Table 4. Input Description (Continued).

| | |
|---|---|
| NWAKHB | Rotor hub wake is generated for analysis<br>= 1 yes<br>= 0 no |
| NWAKSK | Blade shank wake is generated for analysis<br>= 1 yes<br>= 0 no |
| NWAKBL | Rotor blade wake is generated for analysis<br>= 1 yes<br>= 0 no |

If (NWAKHB + NWAKSK + NWAKBL) $\neq 0$, use Data 25; otherwise, skip.

Data 25: FORMAT (2A4,15,2F8.3) (Subroutine DATA)

| | |
|---|---|
| GG(2) | Remarks |
| NSPIRAL | Number of elements along one rotor wake spiral |
| SPIRAL | Number of rotor wake spirals |
| UWAKE | Induced rotor velocity = $\sqrt{1/2\ C_T}\ \Omega R$ |

If NWAKPY = 1, use Data 26-27; otherwise, skip.

Data 26: FORMAT (2A4,1015) (Subroutine DATA)

| | |
|---|---|
| GG(2) | Remarks |
| NSTAG | Vortex layer from separation line is considered for analysis<br>= 1 yes<br>= 0 no |
| NVORT | Isolated vortex (branch wake) is considered for analysis<br>= 1 yes<br>= 0 no |

Data 27: FORMAT (2A4,7F8.3) (Subroutine DATA)

| | |
|---|---|
| GG(2) | Remarks |
| CSTAG | Intensity of the vortex layer from separation line |
| CVORT | Intensity of the isolated vortex (branch wake) |

Table 4. Input Description (Continued).

Data 28: FORMAT (2A4,10I5) (Subroutine DATA)

| | |
|---|---|
| GG(2) | Remarks |
| KPRINT(I) | Output control code<br>= 1 yes<br>= 0 no<br>I = 1 specification of the problem<br>I = 2 nodal numbering of surfaces and corner nodal numbering of elements<br>I = 3 Cartesian coordinates of the nodes<br>I = 4 Cartesian coordinates of the centroids of the element<br>I = 5 coefficient matrix AA<br>I = 6 source integrals<br>I = 7 velocity potential distributions<br>I = 8 perturbation velocity distributions<br>I = 9 pressure coefficients<br>I = 10 lift and induced drag coefficients |

If NBODY1 = 1, use Data 29; otherwise, skip.

Data 29: FORMAT (2A4,10I5) (Subroutine DATA)

| | |
|---|---|
| GG(2) | Remarks |
| NX(KS) | Number of elements in x direction |
| NY(KS) | Number of elements in y direction |
| KNSELE | Define the variation of element size<br>= 0 define by input<br>= 1 uniform along x direction<br>= 2 quadratic along x direction |
| KNSSHP | Defines nose shape<br>= 1; $r = R\,[\xi]^{1/2}$<br>= 2; $r = R\,[\xi]^{1/3}$<br>= 3; $r = R\,[\xi]^{1/4}$ |
| KNSTYP | Defines nose type<br>= 1 circular cross section<br>= 2 elliptical cross section |

Table 4. Input Description (Continued).

If NBODY2 = 1, use Data 30; otherwise, skip.

Data 30: FORMAT (2A4,10I5) (Subroutine DATA)

| | |
|---|---|
| GG(2) | Remarks |
| NX(KS) | Number of elements in x direction |
| NY(KS) | Number of elements in y direction |
| KBDELE | Defines the variation of element size<br>= 0 define by input<br>= 1 uniform along x direction<br>= 2 quadratic along x direction |
| KBDSHP | Defines the fuselage shape<br>= 1 cylindrical |
| KBDTYP | Defines the fuselage type<br>= 1 circular cross section<br>= 2 elliptical cross section |

If NBODY3 = 1, use Data 31; otherwise, skip.

Data 31: FORMAT (2A4,10I5) (Subroutine DATA)

| | |
|---|---|
| GG(2) | Remarks |
| NX(KS) | Number of elements in x direction |
| NY(KS) | Number of elements in y direction |
| KTNELE | Defines the variation of element size<br>= 0 define by input<br>= 1 uniform along x direction<br>= 2 quadratic along x direction |
| KTNSHP | Defines aft-body shape<br>= 1; $r = R\sqrt{\xi}$<br>= 2; $r = R\,[\xi]^{1/3}$<br>= 3; $r = R\,[\xi]^{1/4}$ |
| KTNTYP | Defines aft-body type<br>= 1 circular cross section<br>= 2 elliptical cross section |

Table 4. Input Description (Continued).

If NPYLON = 1, use Data 32; otherwise, skip.

Data 32: FORMAT (2A4,10I5) (Subroutine DATA)

| | |
|---|---|
| GG(2) | Remarks |
| NX(KS) | Number of elements in radial direction |
| NY(KS) | Number of elements in circumferential direction |
| KPYELE | Defines the variation of element size<br>= 0 define by input<br>= 1 uniform element distribution along radial and circumferential direction<br>= 2 quadratic along radial direction with uniform element distribution in circumferential direction |
| KPYSHP | Defines pylon shape<br>= 1 elliptical |
| KPYTYP | Defines pylon type<br>= 1 elliptical |

If NVTAIL = 1, use Data 33; otherwise, skip.

Data 33: FORMAT (2A4,10I5) (Subroutine DATA)

| | |
|---|---|
| GG(2) | Remarks |
| NX(KS) | Number of elements in x direction |
| NY(KS) | Number of elements in y direction |
| KVTELE | Defines the variation of element size<br>= 0 define by input<br>= 1 uniform element distribution along axial and spanwise direction<br>= 2 nonuniform (quadratic) element distribution along axial and span-wise direction<br>= 3 quadratic along spanwise direction with uniform element distribution in axial direction<br>= 4 quadratic along axial direction with uniform element distribution in spanwise direction |

Table 4. Input Description (Continued).

KVTSHP — Defines vertical tail shape

= 1 circular biconvex airfoil

$$Z = \pm \left\{ \left[ \frac{\left(\frac{c}{2}\right)^2 + \tau_{max}^2}{2\,\tau_{max}} \right]^2 - \left[ X - \frac{X_{LE} + X_{TE}}{2} \right]^2 \right\}^{1/2} - \left[ \frac{\left(\frac{c}{2}\right)^2 - \tau_{max}^2}{2\,\tau_{max}} \right]$$

= 2 define by following equation

$$Z = \pm \bar{\tau} \left\{ \sqrt{\left(\frac{X}{X_{TE} - X_{LE}}\right)} \left(1 - \frac{X}{X_{TE} - X_{LE}}\right) \sqrt{1 - \frac{y}{s}} \right\}$$

= 3 define by following equation

$$Z = \pm (4\,\tau)(2\,C_o) \left\{ \left(\frac{X}{X_{TE} - X_{LE}}\right) \left(1 - \frac{X}{X_{TE} - X_{LE}}\right) \sqrt{1 - \frac{y}{s}} \right\}$$

Table 4. Input Description (Continued).

| | | |
|---|---|---|
| | KVTSHP (Cont.) | where |
| | | $c$ = chord length |
| | | $X_{LE}$ = x components of sectional leading edge |
| | | $X_{TE}$ = x components of sectional trailing edge |
| | | $y$ = spanwise location of the section |
| | | $S$ = half span |
| | | $\bar{\tau} = \tau_{max} \left( \frac{3}{4} \sqrt{3} \right) (2\ C_o)$ |
| | | $C_o$ = root chord |
| | KVTTYP | Define vertical tail type<br>= 1 |

If NSHAFT = 1, use Data 34; otherwise, skip.

| | | | |
|---|---|---|---|
| Data 34: | FORMAT (2A4,10I5) | | (Subroutine DATA) |
| | GG(2) | Remarks | |
| | NX(KS) | Number of elements in shaft direction | |
| | NY(KS) | Number of elements in circumferential direction | |
| | KSHELE | Defines the variation of element size<br>= 0 define by input<br>= 1 uniform element distribution | |
| | KSHSHP | Defines rotor shaft shape<br>= 1 cylindrical | |
| | KSHTYP | Defines rotor shaft type<br>= 1 circular cross section | |

Table 4. Input Description (Continued).

If NHUB = 1, use Data 35; otherwise, skip.

Data 35: FORMAT (2A4,10I5) (Subroutine DATA)

| | |
|---|---|
| GG(2) | Remarks |
| NX(KS) | Number of elements in x direction |
| NY(KS) | Number of elements in circumferential direction |
| KHBELE | Defines the variation of element size<br>= 0 define by input<br>= 1 uniform element distribution |
| KHBSHP | Defines rotor hub shape<br>= 1 elliptical |
| KHBTYP | Defines rotor hub type<br>= 1 elliptical |

If NSHANK = 1, use Data 36; otherwise, skip.

Data 36: FORMAT (2A4,10I5) (Subroutine DATA)

| | |
|---|---|
| GG(2) | Remarks |
| NX(KS) | Number of elements in shank direction |
| NY(KS) | Number of elements in circumferential direction |
| KSKELE | Defines the variation of element size<br>= 0 define by input<br>= 1 uniform element distribution |
| KSKSHP | Defines blade shank shape<br>= 1 cylindrical |
| KSKTYP | Defines blade shank type<br>= 1 circular cross section |

If NBLADE = 1, use Data 37; otherwise, skip.

Data 37: FORMAT (2A4,10I5) (Subroutine DATA)

| | |
|---|---|
| GG(2) | Remarks |
| NX(KS) | Number of elements in x direction |

Table 4. Input Description (Continued).

NY(KS) — Number of elements in y direction

KBLELE — Defines the variation of element size
= 0 define by input
= 1 uniform element distribution
= 2 nonuniform (quadratic) element distribution

KBLSHP — Defines rotor blade shape
= 1 circular biconvex airfoil

$$Z = \pm \left\{ \left[ \frac{\left(\frac{c}{2}\right)^2 + \tau_{max}^2}{2\,\tau_{max}} \right]^2 - \left[ X - \frac{X_{LE} + X_{TE}}{2} \right]^2 \right\}^{1/2} - \frac{\left(\frac{c}{2}\right)^2 - \tau_{max}^2}{2\,\tau_{max}}$$

= 2 define by following equation

$$Z = \pm\, \bar{\tau} \left\{ \sqrt{\left(\frac{X}{X_{TE} - X_{LE}}\right)} \left(1 - \frac{X}{X_{TE} - X_{LE}}\right) \sqrt{1 - \frac{r}{R}} \right\}$$

= 3 define by following equation

$$Z = \pm\, (4\tau)\,(2\,C_o) \left\{ \left(\frac{X}{X_{TE} - X_{LE}}\right) \left(1 - \frac{X}{X_{TE} - X_{LE}}\right) \sqrt{1 - \frac{r}{R}} \right\}$$

Table 4. Input Description (Continued).

| | | |
|---|---|---|
| KBLSHP (Cont.) | | where<br>$c$ = blade chord<br>$X_{LE}$ = x components of blade leading edge<br>$X_{TE}$ = x components of blade trailing edge<br>$r$ = radial location<br>$R$ = rotor radius<br>$\bar{\tau} = \tau_{max} \left(\frac{3}{4}\sqrt{3}\right)(2\,C_o)$<br>$C_o$ = blade root chord |
| KBLTYP | | Defines rotor blade type = 1 |

If NPYLON = 1, use Data 38-39; otherwise, skip.

| | | |
|---|---|---|
| Data 38: | FORMAT (10F8.3) | (Subroutine COODPT) |
| | HCSI(IX) | Normalized x direction nodal line coordinates [ Note that HCSI(IX), IX = 1, NXP is implied with NXP denoting the number of nodal lines along the x direction] |
| Data 39: | FORMAT (10F8.3) | (Subroutine COODPT) |
| | HETA(IY) | Normalized y direction nodal line coordinates [ Note that HETA(IY), = 1, NYP is implied with NYP denoting the number of nodal lines along the y direction] |

If NVTAIL = 1, use Data 40-41; otherwise, skip.

| | | |
|---|---|---|
| Data 40: | FORMAT (10F8.3) | (Subroutine COODPT) |
| | HCSI(IX) | Normalized x direction nodal line coordinates [ Note that HCSI(IX), IX = 1, NXP is implied with NXP denoting the number of nodal lines along the x direction] |

Table 4. Input Description (Continued).

| | | | |
|---|---|---|---|
| Data 41: | FORMAT (10F8.3) | | (Subroutine COODPT) |
| | HETA(IY) | Normalized y direction nodal line coordinates [ Note that HETA(IY), IY = 1, NYP is implied with NYP denoting the number of nodal lines along the y direction] | |

If NSHAFT = 1, use Data 42–43; otherwise, skip.

| | | | |
|---|---|---|---|
| Data 42: | FORMAT (10F8.3) | | (Subroutine COODPT) |
| | HCSI(IX) | Normalized x direction nodal line coordinates [ Note that HCSI(IX), IX = 1, NXP is implied with NXP denoting the number of nodal lines along the x direction] | |
| Data 43: | FORMAT (10F8.3) | | (Subroutine COODPT) |
| | HETA(IY) | Normalized y direction nodal line coordinates [ Note that HETA(IY), IY = 1, NYP is implied with NYP denoting the number of nodal lines along the y direction] | |

If NHUB = 1, use Data 44–45; otherwise, skip.

| | | | |
|---|---|---|---|
| Data 44: | FORMAT (10F8.3) | | (Subroutine COODPT) |
| | HCSI(IX) | Normalized x direction nodal line coordinates [ Note that HCSI(IX), IX = 1, NXP is implied with NXP denoting the number of nodal lines along the x direction] | |
| Data 45: | FORMAT (10F8.3) | | (Subroutine COODPT) |
| | HETA(IY) | Normalized y direction nodal line coordinates [ Note that HETA(IY), IY = 1, NYP is implied with NYP denoting the number of nodal lines along the y direction] | |

If NSHANK = 1, use Data 46–47; otherwise, skip.

| | | | |
|---|---|---|---|
| Data 46: | FORMAT (10F8.3) | | (Subroutine COODPT) |
| | HCSI(IX) | Normalized x direction nodal line coordinates [ Note that HCSI(IX), IX = 1, NXP is implied with NXP denoting the number of nodal lines along the x direction] | |

Table 4. Input Description (Continued).

Data 47: FORMAT (10F8.3) (Subroutine COODPT)

| | | |
|---|---|---|
| | HETA(IY) | Normalized y direction nodal line coordinates [ Note that HETA(IY), IY = 1, NYP is implied with NYP denoting the number of nodal lines along the y direction] |

If NBLADE = 1, use Data 48-49; otherwise, skip.

Data 48: FORMAT (10F8.3) (Subroutine COODPT)

| | | |
|---|---|---|
| | HCSI(IX) | Normalized x direction nodal line coordinates [ Note that HCSI(IX), IX = 1, NXP is implied with NXP denoting the number of nodal lines along the x direction] |

Data 49: FORMAT (10F8.3) (Subroutine COODPT)

| | | |
|---|---|---|
| | HETA(IY) | Normalized y direction nodal line coordinates [ Note that HETA(IY), IY = 1, NYP is implied with NYP denoting the number of nodal lines along the y direction] |

If KREAD = 1, use Data 50; otherwise, skip.

Data 50: FORMAT (3E12.4) (Subroutine COODPT)

| | | |
|---|---|---|
| | XK(K,INODE) | The nodal coordinates in global Cartesian system [ Note that (XK(K,INODE), K = 1,3), INODE = 1, NNODE) is implied] |

If NWAKPY = 1 and NSTAG = 1, use Data 51-54; otherwise, skip.

Data 51: FORMAT (3E12.4) (Subroutine COODPT)

YPP(K)

Data 52: FORMAT (3E12.4)

YPM(K)

Data 53: FORMAT (3E12.4)

YMP(K)

Data 54: FORMAT (3E12.4)

YMM(K)

The separation wake nodal coordinates in global Cartesian system [ Note that K=1,3 is implied]

Table 4. Input Description (Concluded).

If NWAKPY = 1 and NVORT = 1, use Data 55-58; otherwise, skip.

| | | | |
|---|---|---|---|
| Data 55: | FORMAT (3E12.4) | | (Subroutine COEFF) |
| | YPP(K) | $\left.\begin{array}{l} \\ \\ \\ \\ \\ \\ \end{array}\right\}$ The isolated vortex branch wake nodal coordinates in global Cartesian system [ Note that K=1,3 is implied] | |
| Data 56: | FORMAT (3E12.4) | | |
| | YPM(K) | | |
| Data 57: | FORMAT (3E12.4) | | |
| | YMP(K) | | |
| Data 58: | FORMAT (3E12.4) | | |
| | YMM(K) | | |

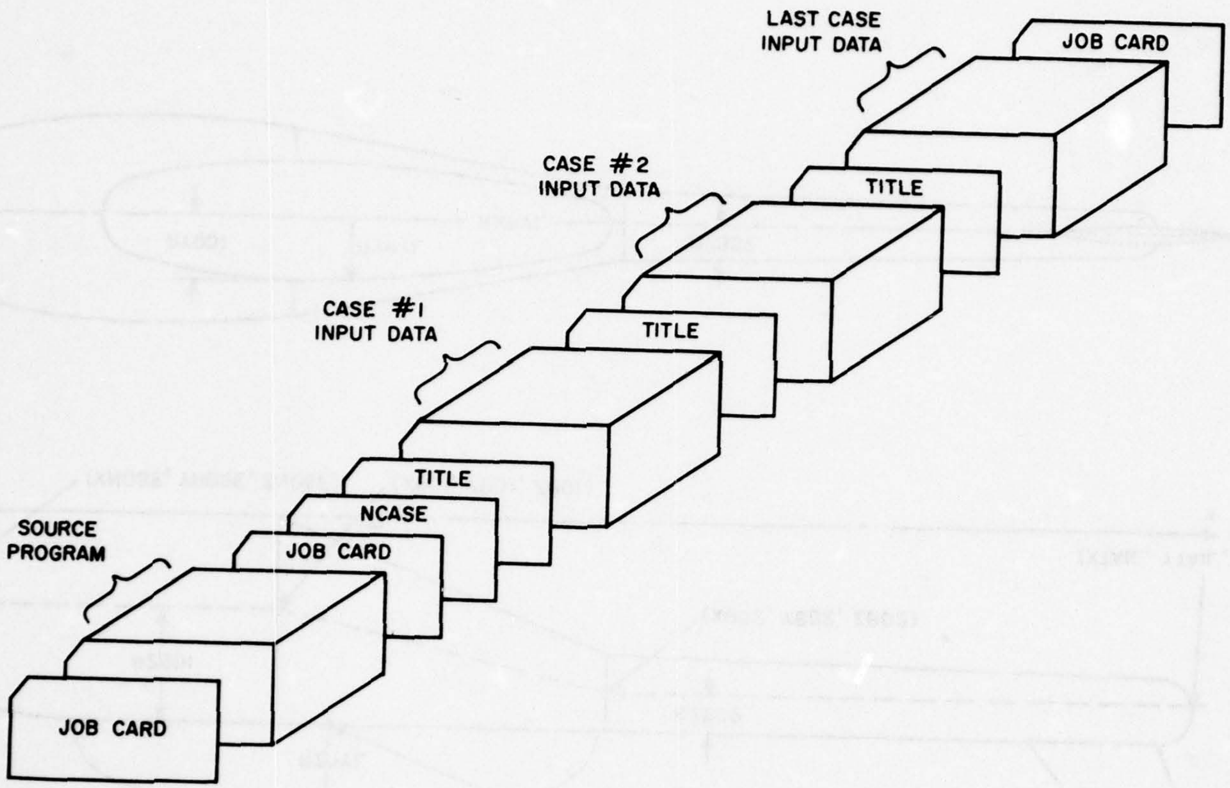



Figure 5. Program SHAPES Data Setup.

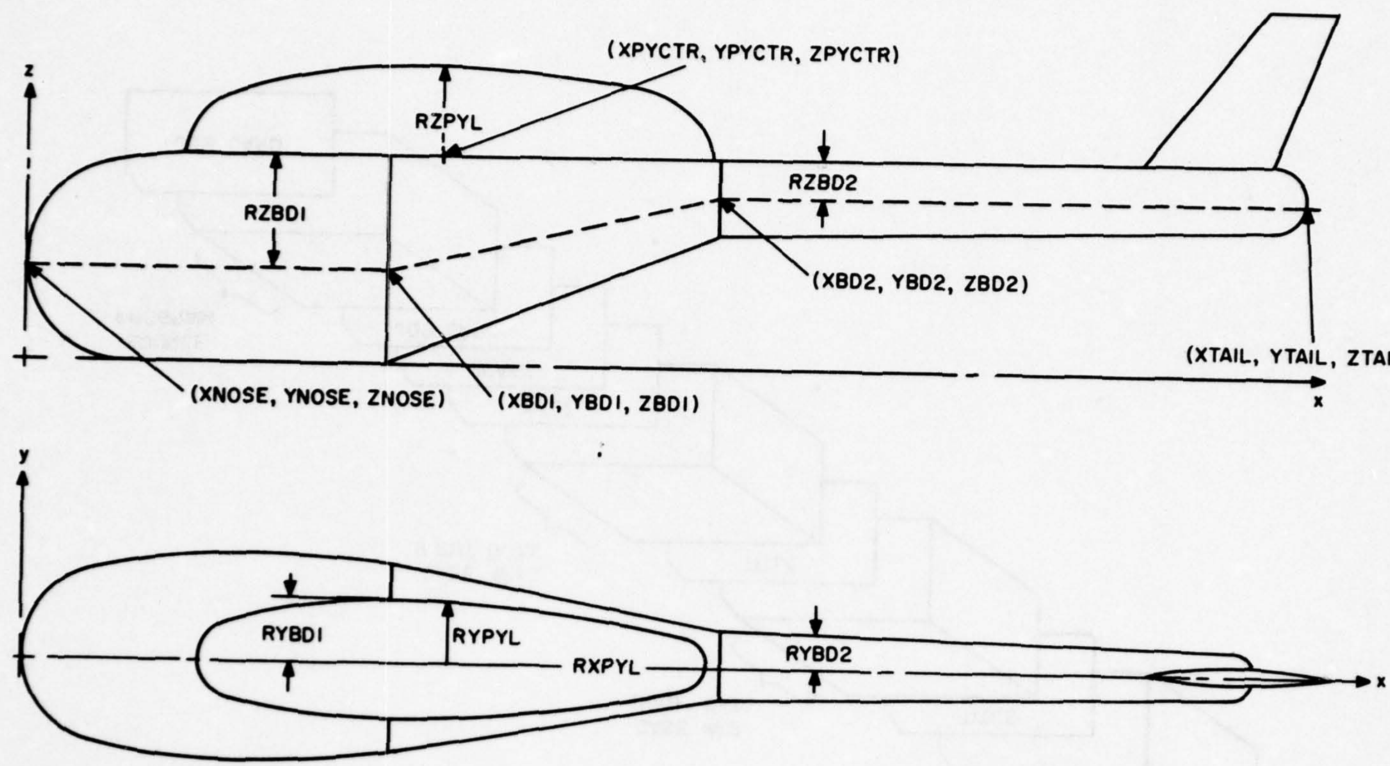



Figure 6. Basic Geometric Inputs for Helicopter Fuselage.

## 4.2 ERROR CODES

To insure proper data are read in and to minimize unnecessary computer time, SHAPES contains several debugging statements at specified checkpoints. If an inconsistency among input data or violation of the input specification is detected, an error code will be printed and the computer run terminated. Table 5 summarizes these error codes.

Table 5. Error Codes Summary.

| Code Number | Description |
|---|---|
| 100 | Mach number is greater than 1 (Present SOUSSA is a subsonic program)<br>(DATA) |
| 200 | NS ≠ (NPYLON + NVTAIL)*MULTY<br>+ (NBODY1 + NBODY2 +<br>(NBODY3)*MULT*MULTY<br>+ (NSHAFT*MULTY<br>+ (NHUB*MULT*MULTY*<br>+ KBLADE*(NSHANK + NBLADE*MULT)<br>(DATA) |
| 300 | Number of elements in the x direction of a sub-surface exceeds the maximum permissible value. This is limited by the storage capacity of the computer. The user has the option of changing the value of NXMAX and NYMAX defined in the main program.<br>(DATA) |
| 400 | Same as code number 300 except for the y direction.<br>(DATA) |
| 500 | Total number of elements required for analysis exceeds the maximum limit specified in the main program.<br>(DATA) |
| IER | IBM subroutine GELG provides error code<br>= 0 no error<br>= 1 no result is obtained because the number of equations is less than 1 or the pivoting element at any elimination step equals 0<br>= N warning is indicated because of a possible loss of significant figures at elimination step N+1 where the pivoting element is less than equal to the specified tolerance times the magnitude of the greatest element of matrix A<br>(DATA) |

## SECTION 5

## PROGRAM OUTPUT

In Program SHAPES several output options are available and these are briefly summarized here. The amount of output required to be printed out is controlled by Data 28, described in Subsection 4.1. Among the information available is the specification of the problem defined by the user and the basic geometric inputs to the problem, i.e., overall dimensions and shapes used to model a helicopter configuration. In addition, the nodal numbering of the aerodynamic breakup as well as the Cartesian coordinate location of the nodal points and the centroid of each aerodynamic panel can be requested. Furthermore, the coefficient matrix and source distribution can be output. Also, the perturbation potential, velocity, and the pressure coefficient are available as outputs. Finally, the lift and induced drag can be requested.

# SECTION 6

# PROGRAM LISTING

## SAMPLE CASE 1:

## SINGLE-BLADE ROTOR

### Data Input

```
  3
PROGRAM SHAPES
HUB PYLON FLOW SEPARATION
SINGLE ROTOR BLADE PROBLEM
KREAD       0
9           2     1     0
99          0     0     0     0     0     0     0     0     1
999         0     0
UMACH         0.000    355.030
ALFA          6.000      6.000
ROTOR        17.500      2.330      0.000      1.093      0.000      0.300      .050
THETAS        0.023      6.030      6.000      1.350     90.600
RPITCH       10.610      0.070
KBLADE      1     1
NWAKE       0     0     0     1
SPIRAL     10       3.000      20.000
KPRINT      1     1     1     1     0     1     1     1     1     1
NROTOR      3     7     2     1     1

      DATA

   NELEM =      42

   IS=    1 NX=     3 NY=     7 NXY=    21  ISFACE=     1 NT=     0 KNORML=    1 KWAKES=    1 KROTORS=    1
   IS=    2 NX=     3 NY=     7 NXY=    21  ISFACE=     2 NT=    21 KNORML=   -1 KWAKES=    1 KROTORS=    1

      PREPRO
   NNODE=   46
```

### Specifications of the Problem

```
FOR PART   24
NX= 3
NY= 7

FOR PART   25
NX= 3
NY= 7

NELEM= 42

KSYMMY= 1
KSYMMZ= 0
```

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## X, Y, and Z Coordinates of the Nodes

| NODE= | X | Y | Z |
|---|---|---|---|
| 1 | 0.00000 | 2.33000 | 0.00000 |
| 2 | .12025 | 2.33000 | -.01163 |
| 3 | .47803 | 2.33000 | -.06234 |
| 4 | 1.06448 | 2.33000 | -.19941 |
| 5 | 0.00000 | 6.35469 | 0.00000 |
| 6 | .12025 | 6.35469 | -.01163 |
| 7 | .47803 | 6.35469 | -.06234 |
| 8 | 1.06448 | 6.35469 | -.19941 |
| 9 | 0.00000 | 9.76020 | 0.00000 |
| 10 | .12025 | 9.76020 | -.01163 |
| 11 | .47803 | 9.76020 | -.06234 |
| 12 | 1.06448 | 9.76020 | -.19941 |
| 13 | 0.00000 | 12.54553 | 0.00000 |
| 14 | .12025 | 12.54553 | -.01163 |
| 15 | .47803 | 12.54553 | -.06234 |
| 16 | 1.06448 | 12.54553 | -.19941 |
| 17 | 0.00000 | 14.71367 | 0.00000 |
| 18 | .12025 | 14.71367 | -.01163 |
| 19 | .47803 | 14.71367 | -.06234 |
| 20 | 1.06448 | 14.71367 | -.19941 |
| 21 | 0.00000 | 16.26163 | 0.00000 |
| 22 | .12025 | 16.26163 | -.01163 |
| 23 | .47803 | 16.26163 | -.06234 |
| 24 | 1.06448 | 16.26163 | -.19941 |
| 25 | 0.00000 | 17.19041 | 0.00000 |
| 26 | .12025 | 17.19041 | -.01163 |
| 27 | .47803 | 17.19041 | -.06234 |
| 28 | 1.06448 | 17.19041 | -.19941 |
| 29 | 0.00000 | 17.50000 | 0.00000 |
| 30 | .11628 | 17.50000 | -.02216 |
| 31 | .47319 | 17.50000 | -.06862 |
| 32 | 1.06448 | 17.50000 | -.19941 |
| 33 | .11630 | 2.33000 | -.03269 |
| 34 | .46818 | 2.33000 | -.11491 |
| 35 | .11630 | 6.35469 | -.03269 |
| 36 | .46818 | 6.35469 | -.11491 |
| 37 | .11630 | 9.76020 | -.03269 |
| 38 | .46818 | 9.76020 | -.11491 |
| 39 | .11630 | 12.54553 | -.03269 |
| 40 | .46818 | 12.54553 | -.11491 |
| 41 | .11630 | 14.71367 | -.03269 |
| 42 | .46818 | 14.71367 | -.11491 |
| 43 | .11630 | 16.26163 | -.03269 |
| 44 | .46818 | 16.26163 | -.11491 |
| 45 | .11630 | 17.19041 | -.03269 |
| 46 | .46818 | 17.19041 | -.11491 |

## X, Y, and Z Coordinates of the Centroid of Aerodynamic Panels

| ELEM= | XPC | YPC | ZPC |
|---|---|---|---|
| 1 | .06012 | 4.34235 | -.00581 |
| 2 | .29914 | 4.34235 | -.03698 |
| 3 | .77126 | 4.34235 | -.13087 |
| 4 | .06012 | 8.05745 | -.00581 |
| 5 | .29914 | 8.05745 | -.03698 |
| 6 | .77126 | 8.05745 | -.13087 |
| 7 | .06012 | 11.15337 | -.00581 |
| 8 | .29914 | 11.15337 | -.03698 |
| 9 | .77126 | 11.15337 | -.13087 |
| 10 | .06012 | 13.63010 | -.00581 |
| 11 | .29914 | 13.63010 | -.03698 |
| 12 | .77126 | 13.63010 | -.13087 |
| 13 | .06012 | 15.48765 | -.00581 |
| 14 | .29914 | 15.48765 | -.03698 |
| 15 | .77126 | 15.48765 | -.13087 |
| 16 | .06012 | 16.72602 | -.00581 |
| 17 | .29914 | 16.72602 | -.03698 |
| 18 | .77126 | 16.72602 | -.13087 |
| 19 | .05963 | 17.34520 | -.00845 |
| 20 | .29741 | 17.34520 | -.04819 |
| 21 | .77003 | 17.34520 | -.13744 |
| 22 | .05815 | 4.34235 | -.01634 |
| 23 | .29224 | 4.34235 | -.07380 |
| 24 | .76633 | 4.34235 | -.15716 |
| 25 | .05815 | 8.05745 | -.01634 |
| 26 | .29224 | 8.05745 | -.07380 |
| 27 | .76633 | 8.05745 | -.15716 |
| 28 | .05815 | 11.15337 | -.01634 |
| 29 | .29224 | 11.15337 | -.07380 |
| 30 | .76633 | 11.15337 | -.15716 |
| 31 | .05815 | 13.63010 | -.01634 |
| 32 | .29224 | 13.63010 | -.07380 |
| 33 | .76633 | 13.63010 | -.15716 |
| 34 | .05815 | 15.48765 | -.01634 |
| 35 | .29224 | 15.48765 | -.07380 |
| 36 | .76633 | 15.48765 | -.15716 |
| 37 | .05815 | 16.72602 | -.01634 |
| 38 | .29224 | 16.72602 | -.07380 |
| 39 | .76633 | 16.72602 | -.15716 |
| 40 | .05864 | 17.34520 | -.01371 |
| 41 | .29397 | 17.34520 | -.06459 |
| 42 | .76756 | 17.34520 | -.15059 |

## Nodal Numbering for Surfaces

FOR SURFACE 24

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 5 | 9 | 13 | 17 | 21 | 25 | 29 |
| 2 | 6 | 10 | 14 | 18 | 22 | 26 | 30 |
| 3 | 7 | 11 | 15 | 19 | 23 | 27 | 31 |
| 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 |

FOR SURFACE 25

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 5 | 9 | 13 | 17 | 21 | 25 | 29 |
| 33 | 35 | 37 | 39 | 41 | 43 | 45 | 30 |
| 34 | 36 | 38 | 40 | 42 | 44 | 46 | 31 |
| 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 |

## Nodal Numbering for Elements

| ELEM | ++ | +- | -+ | -- |
|---|---|---|---|---|
| 1 | 6 | 2 | 5 | 1 |
| 2 | 7 | 3 | 6 | 2 |
| 3 | 8 | 4 | 7 | 3 |
| 4 | 10 | 6 | 9 | 5 |
| 5 | 11 | 7 | 10 | 6 |
| 6 | 12 | 8 | 11 | 7 |
| 7 | 14 | 10 | 13 | 9 |
| 8 | 15 | 11 | 14 | 10 |
| 9 | 16 | 12 | 15 | 11 |
| 10 | 18 | 14 | 17 | 13 |
| 11 | 19 | 15 | 18 | 14 |
| 12 | 20 | 16 | 19 | 15 |
| 13 | 22 | 18 | 21 | 17 |
| 14 | 23 | 19 | 22 | 18 |
| 15 | 24 | 20 | 23 | 19 |
| 16 | 26 | 22 | 25 | 21 |
| 17 | 27 | 23 | 26 | 22 |
| 18 | 28 | 24 | 27 | 23 |
| 19 | 30 | 26 | 29 | 25 |
| 20 | 31 | 27 | 30 | 26 |
| 21 | 32 | 28 | 31 | 27 |
| 22 | 33 | 35 | 1 | 5 |
| 23 | 34 | 36 | 33 | 35 |
| 24 | 4 | 8 | 34 | 36 |
| 25 | 35 | 37 | 5 | 9 |
| 26 | 36 | 38 | 35 | 37 |
| 27 | 8 | 12 | 36 | 38 |
| 28 | 37 | 39 | 9 | 13 |
| 29 | 38 | 40 | 37 | 39 |
| 30 | 12 | 16 | 38 | 40 |
| 31 | 39 | 41 | 13 | 17 |
| 32 | 40 | 42 | 39 | 41 |
| 33 | 16 | 20 | 40 | 42 |
| 34 | 41 | 43 | 17 | 21 |
| 35 | 42 | 44 | 41 | 43 |
| 36 | 20 | 24 | 42 | 44 |
| 37 | 43 | 45 | 21 | 25 |
| 38 | 44 | 46 | 43 | 45 |
| 39 | 24 | 28 | 44 | 46 |
| 40 | 45 | 30 | 25 | 29 |
| 41 | 46 | 31 | 45 | 30 |
| 42 | 28 | 32 | 46 | 31 |

## The Distribution of the Source



THE DISTRIBUTION OF SOURCE

FOR SUBSURFACE 24

| | | | | | | |
|---|---|---|---|---|---|---|
| -.54553E+01 | -.98655E+01 | -.13411E+02 | -.16271E+02 | -.10312E+02 | -.10733E+02 | -.10510E+02 |
| -.27443E+01 | -.47637E+01 | -.64467E+01 | -.77902E+01 | -.67494E+01 | -.88877E+01 | -.53715E+01 |
| .40619E+01 | .91132E+01 | .12643E+02 | .15465E+02 | .17480E+02 | .17995E+02 | .93205E+01 |

FOR SUBSURFACE 25

| | | | | | | |
|---|---|---|---|---|---|---|
| -.60686E+01 | -.18951E+02 | -.15012E+02 | -.12247E+02 | -.26565E+02 | -.21201E+02 | -.11787E+02 |
| -.46865E+01 | -.85095E+01 | -.11727E+02 | -.14336E+02 | -.16260E+02 | -.17808E+02 | -.97158E+01 |
| .33064E+01 | .63446E+01 | .87286E+01 | .11639E+02 | .11950E+02 | .12013E+02 | .61640E+01 |

## The Distribution of the Velocity Potential

THE DISTRIBUTION OF THE VELOCITY POTENTIAL

FOR SUBSURFACE 24

| | | | | | | |
|---|---|---|---|---|---|---|
| .57743E+02 | .12076E+03 | .13220E+03 | .13186E+03 | .12223E+03 | .16025E+03 | .94556E+02 |
| .11366E+03 | .14857E+03 | .15739E+03 | .16143E+03 | .15467E+03 | .13902E+03 | .11436E+03 |
| .11917E+03 | .15296E+03 | .17375E+03 | .18066E+03 | .17560E+03 | .15953E+03 | .12516E+03 |

FOR SUBSURFACE 25

| | | | | | | |
|---|---|---|---|---|---|---|
| .66347E+02 | .64186E+02 | .59945E+02 | .47274E+02 | .29063E+02 | .10263E+02 | .27677E+02 |
| .49832E+02 | .40465E+02 | .39531E+02 | .23127E+02 | .34180E+01 | -.62380E+01 | .10612E+02 |
| .44693E+02 | .42095E+02 | .30273E+02 | .12052E+02 | -.70572E+01 | -.13457E+02 | .61821E+01 |

## Pressure Distribution

THE DISTRIBUTION OF CP

FOR SUBSURFACE 24

| | | | | | | |
|---|---|---|---|---|---|---|
| -.80436E+00 | -.13691E+01 | -.14902E+01 | -.25306E+01 | -.28028E+01 | -.28655E+01 | -.13838E+01 |
| -.12658E+00 | -.19535E+00 | -.26234E+00 | -.36065E+00 | -.41152E+00 | -.38549E+00 | -.21216E+00 |
| .22533E+00 | .35278E+00 | .61106E+00 | .65883E+00 | .73322E+00 | .69717E+00 | .20366E+00 |

FOR SUBSURFACE 25

| | | | | | | |
|---|---|---|---|---|---|---|
| .82564E+00 | .12756E+01 | .18370E+01 | .23371E+01 | .26603E+01 | .25863E+01 | .12186E+01 |
| .81657E-01 | .13226E+00 | .19753E+00 | .25337E+00 | .27727E+00 | .24846E+00 | .87001E-01 |
| -.24629E+00 | -.38651E+00 | -.56498E+00 | -.69930E+00 | -.75663E+00 | -.76648E+00 | -.35874E+00 |

# SAMPLE CASE 2:

# XH-51A HELICOPTER ROTOR

## Data Input

```
  3
PROGRAM SHAPES
HUB PYLON FLOW SEPARATION
FOUR BLADED HELICOPTER ROTOR
KREAD      0
*          0    0    0
**         0    0    0    0    0    0    0    0    1
***        0    0
UMACH       0.000    355.[illegible]
ALFA        0.000      0.000
ROTOR      17.500      2.330      0.000      1.003      0.000      0.000      .050
THETTS      0.000      0.000      0.000      0.000     90.000
RPITCH     10.[illegible]      3.000
KBLADE     4    1
NWAKE      0    0    0    1
SPIRAL    10      3.000      39.000
KPRINT     1    1    1    1    0    1    1    1    1    1
NROTOR     5    5    2    1    1

        DATA

    NELEM =    200

    IS=   1 NX=    5 NY=    5 NXY=   25 ISFACE=   1 NT=    0 KNORML=   1 KWAKES=   1 KROTCRS=   1
    IS=   2 NX=    5 NY=    5 NXY=   25 ISFACE=   2 NT=   25 KNORML=  -1 KWAKES=   1 KROTCRS=   1
    IS=   3 NX=    5 NY=    5 NXY=   25 ISFACE=   3 NT=   50 KNORML=   1 KWAKES=   1 KROTCRS=   1
    IS=   4 NX=    5 NY=    5 NXY=   25 ISFACE=   4 NT=   75 KNORML=  -1 KWAKES=   1 KROTCRS=   1
    IS=   5 NX=    5 NY=    5 NXY=   25 ISFACE=   5 NT=  100 KNORML=   1 KWAKES=   1 KROTCRS=   1
    IS=   6 NX=    5 NY=    5 NXY=   25 ISFACE=   6 NT=  125 KNORML=  -1 KWAKES=   1 KROTCRS=   1
    IS=   7 NX=    5 NY=    5 NXY=   25 ISFACE=   7 NT=  150 KNORML=   1 KWAKES=   1 KROTCRS=   1
    IS=   8 NX=    5 NY=    5 NXY=   25 ISFACE=   8 NT=  175 KNORML=  -1 KWAKES=   1 KROTCRS=   1

        PREPRO
    NNODE=  224
```

# Specifications of the Problem

```
FOR PART    24
NX= 5
NY= 5

FOR PART    25
NX= 5
NY= 5

FOR PART    27
NX= 5
NY= 5

FOR PART    28
NX= 5
NY= 5

FOR PART    30
NX= 5
NY= 5

FOR PART    31
NX= 5
NY= 5

FOR PART    33
NX= 5
NY= 5

FOR PART    34
NX= 5
NY= 5

NELEM=200

KSYMMY= 0
KSYMMZ= 0
```

## X, Y, and Z Coordinates of the Nodes

| NODE= | X | Y | Z |
|---|---|---|---|
| 1 | 0.00000 | 2.33000 | 0.00000 |
| 2 | .04335 | 2.33000 | -.00388 |
| 3 | .17300 | 2.33000 | -.01758 |
| 4 | .38791 | 2.33000 | -.04726 |
| 5 | .68587 | 2.33000 | -.10309 |
| 6 | 1.06448 | 2.33000 | -.19941 |
| 7 | 0.00000 | 7.79120 | 0.00000 |
| 8 | .04335 | 7.79120 | -.00388 |
| 9 | .17300 | 7.79120 | -.01758 |
| 10 | .38781 | 7.79120 | -.04726 |
| 11 | .68587 | 7.79120 | -.10309 |
| 12 | 1.06448 | 7.79120 | -.19941 |
| 13 | 0.00000 | 12.03880 | 0.00000 |
| 14 | .04335 | 12.03880 | -.00388 |
| 15 | .17300 | 12.03880 | -.01758 |
| 16 | .38781 | 12.03880 | -.04726 |
| 17 | .68587 | 12.03880 | -.10309 |
| 18 | 1.06448 | 12.03880 | -.19941 |
| 19 | 0.00000 | 15.07280 | 0.00000 |
| 20 | .04335 | 15.07280 | -.00388 |
| 21 | .17300 | 15.07280 | -.01758 |
| 22 | .38781 | 15.07280 | -.04726 |
| 23 | .68587 | 15.07280 | -.10309 |
| 24 | 1.06448 | 15.07280 | -.19941 |
| 25 | 0.00000 | 16.89320 | 0.00000 |
| 26 | .04335 | 16.89320 | -.00388 |
| 27 | .17300 | 16.89320 | -.01758 |
| 28 | .38781 | 16.89320 | -.04726 |
| 29 | .68587 | 16.89320 | -.10309 |
| 30 | 1.06448 | 16.89320 | -.19941 |
| 31 | 0.00000 | 17.50000 | 0.00000 |
| 32 | .04258 | 17.50000 | -.00798 |
| 33 | .17032 | 17.50000 | -.03190 |
| 34 | .38321 | 17.50000 | -.07179 |
| 35 | .68127 | 17.50000 | -.12762 |
| 36 | 1.06448 | 17.50000 | -.19941 |
| 37 | .04131 | 2.33000 | -.01207 |
| 38 | .16763 | 2.33000 | -.04623 |
| 39 | .37862 | 2.33000 | -.09632 |
| 40 | .67667 | 2.33000 | -.15215 |
| 41 | .04181 | 7.79120 | -.01207 |
| 42 | .16763 | 7.79120 | -.04623 |
| 43 | .37862 | 7.79120 | -.09632 |
| 44 | .67667 | 7.79120 | -.15215 |
| 45 | .04181 | 12.03880 | -.01207 |
| 46 | .16763 | 12.03880 | -.04623 |
| 47 | .37862 | 12.03880 | -.09632 |
| 48 | .67667 | 12.03880 | -.15215 |
| 49 | .04181 | 15.07280 | -.01207 |
| 50 | .16763 | 15.07280 | -.04623 |
| 51 | .37862 | 15.07280 | -.09632 |
| 52 | .67667 | 15.07280 | -.15215 |
| 53 | .04181 | 16.89320 | -.01207 |
| 54 | .16763 | 16.89320 | -.04623 |
| 55 | .37862 | 16.89320 | -.09632 |
| 56 | .67667 | 16.89320 | -.15215 |
| 57 | -2.33000 | .00000 | 0.00000 |
| 58 | -2.33000 | .04335 | -.00388 |
| 59 | -2.33000 | .17300 | -.01758 |
| 60 | -2.33000 | .38781 | -.04726 |
| 61 | -2.33000 | .68587 | -.10309 |
| 62 | -2.33000 | 1.06448 | -.19941 |
| 63 | -7.79120 | .00000 | 0.00000 |
| 64 | -7.79120 | .04335 | -.00388 |
| 65 | -7.79120 | .17300 | -.01758 |
| 66 | -7.79120 | .38781 | -.04726 |

| | | | |
|---|---|---|---|
| 67 | -7.79120 | .68587 | -.10309 |
| 68 | -7.79120 | 1.06448 | -.19941 |
| 69 | -12.03880 | .00000 | 0.00000 |
| 70 | -12.03880 | .04335 | -.00388 |
| 71 | -12.03880 | .17300 | -.01758 |
| 72 | -12.03880 | .38781 | -.04726 |
| 73 | -12.03880 | .68587 | -.10309 |
| 74 | -12.03880 | 1.06448 | -.19941 |
| 75 | -15.07280 | .00000 | 0.00000 |
| 76 | -15.07280 | .04335 | -.00388 |
| 77 | -15.07280 | .17300 | -.01758 |
| 78 | -15.07280 | .38781 | -.04726 |
| 79 | -15.07280 | .68587 | -.10309 |
| 80 | -15.07280 | 1.06448 | -.19941 |
| 81 | -16.89320 | .00000 | 0.00000 |
| 82 | -16.89320 | .04335 | -.00388 |
| 83 | -16.89320 | .17300 | -.01758 |
| 84 | -16.89320 | .38781 | -.04726 |
| 85 | -16.89320 | .68587 | -.10309 |
| 86 | -16.89320 | 1.06448 | -.19941 |
| 87 | -17.50000 | .00000 | 0.00000 |
| 88 | -17.50000 | .04258 | -.00798 |
| 89 | -17.50000 | .17032 | -.03190 |
| 90 | -17.50000 | .38321 | -.07179 |
| 91 | -17.50000 | .68127 | -.12762 |
| 92 | -17.50000 | 1.06446 | -.19941 |
| 93 | -2.33000 | .04181 | -.01207 |
| 94 | -2.33000 | .16763 | -.04623 |
| 95 | -2.33000 | .37862 | -.09632 |
| 96 | -2.33000 | .67667 | -.15215 |
| 97 | -7.79120 | .04181 | -.01207 |
| 98 | -7.79120 | .16763 | -.04623 |
| 99 | -7.79120 | .37862 | -.09632 |
| 100 | -7.79120 | .67667 | -.15215 |
| 101 | -12.03880 | .04181 | -.01207 |
| 102 | -12.03880 | .16763 | -.04623 |
| 103 | -12.03880 | .37862 | -.09632 |
| 104 | -12.03880 | .67667 | -.15215 |
| 105 | -15.07280 | .04181 | -.01207 |
| 106 | -15.07280 | .16763 | -.04623 |
| 107 | -15.07280 | .37862 | -.09632 |
| 108 | -15.07280 | .67667 | -.15215 |
| 109 | -16.89320 | .04181 | -.01207 |
| 110 | -16.89320 | .16763 | -.04623 |
| 111 | -16.89320 | .37862 | -.09632 |
| 112 | -16.89320 | .67667 | -.15215 |
| 113 | -.00000 | -2.33000 | 0.00000 |
| 114 | -.04335 | -2.33000 | -.00388 |
| 115 | -.17300 | -2.33000 | -.01758 |
| 116 | -.38781 | -2.33000 | -.04726 |
| 117 | -.68587 | -2.33000 | -.10309 |
| 118 | -1.06448 | -2.33000 | -.19941 |
| 119 | -.00000 | -7.79120 | 0.00000 |
| 120 | -.04335 | -7.79120 | -.00388 |
| 121 | -.17300 | -7.79120 | -.01758 |
| 122 | -.38781 | -7.79120 | -.04726 |
| 123 | -.68587 | -7.79120 | -.10309 |
| 124 | -1.06448 | -7.79120 | -.19941 |
| 125 | -.00000 | -12.03880 | 0.00000 |
| 126 | -.04335 | -12.03880 | -.00388 |
| 127 | -.17300 | -12.03880 | -.01758 |
| 128 | -.38781 | -12.03880 | -.04726 |
| 129 | -.68587 | -12.03880 | -.10309 |
| 130 | -1.06448 | -12.03880 | -.19941 |
| 131 | -.00000 | -15.07280 | 0.00000 |
| 132 | -.04335 | -15.07280 | -.00388 |
| 133 | -.17300 | -15.07280 | -.01758 |
| 134 | -.38781 | -15.07280 | -.04726 |
| 135 | -.68587 | -15.07280 | -.10309 |
| 136 | -1.06448 | -15.07280 | -.19941 |
| 137 | -.00000 | -16.89320 | 0.00000 |
| 138 | -.04335 | -16.89320 | -.00388 |
| 139 | -.17300 | -16.89320 | -.01758 |
| 140 | -.38781 | -16.89320 | -.04726 |

| | | | |
|---|---|---|---|
| 141 | -.68587 | -16.89320 | -.10309 |
| 142 | -1.06448 | -16.89320 | -.19941 |
| 143 | -.00000 | -17.50000 | 0.00000 |
| 144 | -.04258 | -17.50000 | -.00798 |
| 145 | -.17032 | -17.50000 | -.03190 |
| 146 | -.38321 | -17.50000 | -.07179 |
| 147 | -.68127 | -17.50000 | -.12762 |
| 148 | -1.06448 | -17.50000 | -.19941 |
| 149 | -.04181 | -2.33000 | -.01207 |
| 150 | -.16763 | -2.33000 | -.04623 |
| 151 | -.37862 | -2.33000 | -.09632 |
| 152 | -.67667 | -2.33000 | -.15215 |
| 153 | -.04181 | -7.79120 | -.01207 |
| 154 | -.16763 | -7.79120 | -.04623 |
| 155 | -.37862 | -7.79120 | -.09632 |
| 156 | -.67667 | -7.79120 | -.15215 |
| 157 | -.04181 | -12.03880 | -.01207 |
| 158 | -.16763 | -12.03880 | -.04623 |
| 159 | -.37862 | -12.03880 | -.09632 |
| 160 | -.67667 | -12.03880 | -.15215 |
| 161 | -.04181 | -15.07280 | -.01207 |
| 162 | -.16763 | -15.07280 | -.04623 |
| 163 | -.37862 | -15.07280 | -.09632 |
| 164 | -.67667 | -15.07280 | -.15215 |
| 165 | -.04181 | -16.89320 | -.01207 |
| 166 | -.16763 | -15.89320 | -.04623 |
| 167 | -.37862 | -16.89320 | -.09632 |
| 168 | -.67667 | -16.89320 | -.15215 |
| 169 | 2.33000 | -.00000 | 0.00000 |
| 170 | 2.33000 | -.04335 | -.00388 |
| 171 | 2.33000 | -.17300 | -.01758 |
| 172 | 2.33000 | -.38781 | -.04728 |
| 173 | 2.33000 | -.68587 | -.10309 |
| 174 | 2.33000 | -1.06448 | -.19941 |
| 175 | 7.79120 | -.00000 | 0.00000 |
| 176 | 7.79120 | -.04335 | -.00388 |
| 177 | 7.79120 | -.17300 | -.01758 |
| 178 | 7.79120 | -.38781 | -.04728 |
| 179 | 7.79120 | -.68587 | -.10309 |
| 180 | 7.79120 | -1.06448 | -.19941 |
| 181 | 12.03880 | -.00000 | 0.00000 |
| 182 | 12.03880 | -.04335 | -.00388 |
| 183 | 12.03880 | -.17300 | -.01758 |
| 184 | 12.03880 | -.38781 | -.04728 |
| 185 | 12.03880 | -.68587 | -.10309 |
| 186 | 12.03880 | -1.06448 | -.19941 |
| 187 | 15.07280 | -.00000 | 0.00000 |
| 188 | 15.07280 | -.04335 | -.00388 |
| 189 | 15.07280 | -.17300 | -.01758 |
| 190 | 15.07280 | -.38781 | -.04728 |
| 191 | 15.07280 | -.68587 | -.10309 |
| 192 | 15.07280 | -1.06448 | -.19941 |
| 193 | 16.89320 | -.00000 | 0.00000 |
| 194 | 16.89320 | -.04335 | -.00388 |
| 195 | 16.89320 | -.17300 | -.01758 |
| 196 | 16.89320 | -.38781 | -.04728 |
| 197 | 16.89320 | -.68587 | -.10309 |
| 198 | 16.89320 | -1.06448 | -.19941 |
| 199 | 17.50000 | -.00000 | 0.00000 |
| 200 | 17.50000 | -.04258 | -.00798 |
| 201 | 17.50000 | -.17032 | -.03190 |
| 202 | 17.50000 | -.38321 | -.07179 |
| 203 | 17.50000 | -.68127 | -.12762 |
| 204 | 17.50000 | -1.06448 | -.19941 |
| 205 | 2.33000 | -.04181 | -.01207 |
| 206 | 2.33000 | -.16763 | -.04623 |
| 207 | 2.33000 | -.37862 | -.09632 |
| 208 | 2.33000 | -.67667 | -.15215 |
| 209 | 7.79120 | -.04181 | -.01207 |
| 210 | 7.79120 | -.16763 | -.04623 |
| 211 | 7.79120 | -.37862 | -.09632 |
| 212 | 7.79120 | -.67667 | -.15215 |
| 213 | 12.03880 | -.04181 | -.01207 |
| 214 | 12.03880 | -.16763 | -.04623 |

| | | | |
|---|---|---|---|
| 215 | 12.03880 | -.37862 | -.09632 |
| 216 | 12.03880 | -.67667 | -.15215 |
| 217 | 15.07280 | -.04181 | -.01207 |
| 218 | 15.07280 | -.16753 | -.04623 |
| 219 | 15.07280 | -.37862 | -.09632 |
| 220 | 15.07230 | -.67667 | -.15215 |
| 221 | 16.89320 | -.04181 | -.01207 |
| 222 | 16.89320 | -.16763 | -.04623 |
| 223 | 16.89320 | -.37862 | -.09632 |
| 224 | 16.89320 | -.67667 | -.15215 |

## X, Y, and Z Coordinates of the Centroid of Aerodynamic Panels

| ELEM= | XPC | YPC | ZPC |
|---|---|---|---|
| 1 | .02167 | 5.06060 | -.00194 |
| 2 | .10817 | 5.06060 | -.01073 |
| 3 | .28041 | 5.06060 | -.03242 |
| 4 | .53684 | 5.06060 | -.07517 |
| 5 | .87517 | 5.06060 | -.15125 |
| 6 | .02167 | 9.91500 | -.00194 |
| 7 | .10817 | 9.91500 | -.01073 |
| 8 | .28041 | 9.91500 | -.03242 |
| 9 | .53684 | 9.91500 | -.07517 |
| 10 | .87517 | 9.91500 | -.15125 |
| 11 | .02167 | 13.55580 | -.00194 |
| 12 | .10817 | 13.55580 | -.01073 |
| 13 | .28041 | 13.55580 | -.03242 |
| 14 | .53684 | 13.55580 | -.07517 |
| 15 | .87517 | 13.55580 | -.15125 |
| 16 | .02167 | 15.98300 | -.00194 |
| 17 | .10817 | 15.98300 | -.01073 |
| 18 | .28041 | 15.98300 | -.03242 |
| 19 | .53684 | 15.98300 | -.07517 |
| 20 | .87517 | 15.98300 | -.15125 |
| 21 | .02148 | 17.19660 | -.00296 |
| 22 | .10731 | 17.19660 | -.01534 |
| 23 | .27859 | 17.19660 | -.04213 |
| 24 | .53454 | 17.19660 | -.08744 |
| 25 | .87403 | 17.19660 | -.15738 |
| 26 | .02091 | 5.06060 | -.00604 |
| 27 | .10472 | 5.06060 | -.02915 |
| 28 | .27313 | 5.06060 | -.07127 |
| 29 | .52765 | 5.06060 | -.12423 |
| 30 | .87058 | 5.06060 | -.17578 |
| 31 | .02091 | 9.91500 | -.00604 |
| 32 | .10472 | 9.91500 | -.02915 |
| 33 | .27313 | 9.91500 | -.07127 |
| 34 | .52765 | 9.91500 | -.12423 |
| 35 | .87058 | 9.91500 | -.17578 |
| 36 | .02091 | 13.55580 | -.00604 |
| 37 | .10472 | 13.55580 | -.02915 |
| 38 | .27313 | 13.55580 | -.07127 |
| 39 | .52765 | 13.55580 | -.12423 |
| 40 | .87058 | 13.55580 | -.17578 |
| 41 | .02091 | 15.98300 | -.00604 |
| 42 | .10472 | 15.98300 | -.02915 |
| 43 | .27313 | 15.98300 | -.07127 |
| 44 | .52765 | 15.98300 | -.12423 |
| 45 | .87058 | 15.98300 | -.17578 |
| 46 | .02110 | 17.19660 | -.00501 |
| 47 | .10559 | 17.19660 | -.02455 |
| 48 | .27495 | 17.19660 | -.06156 |
| 49 | .52994 | 17.19660 | -.11197 |
| 50 | .87173 | 17.19660 | -.16964 |
| 51 | -5.06060 | .02167 | -.00194 |
| 52 | -5.06060 | .10817 | -.01073 |
| 53 | -5.06060 | .28041 | -.03242 |
| 54 | -5.06060 | .53684 | -.07517 |
| 55 | -5.06060 | .87517 | -.15125 |
| 56 | -9.91500 | .02167 | -.00194 |
| 57 | -9.91500 | .10817 | -.01073 |
| 58 | -9.91500 | .28041 | -.03242 |
| 59 | -9.91500 | .53684 | -.07517 |
| 60 | -9.91500 | .87517 | -.15125 |
| 61 | -13.55580 | .02167 | -.00194 |
| 62 | -13.55580 | .10817 | -.01073 |
| 63 | -13.55580 | .28041 | -.03242 |
| 64 | -13.55580 | .53684 | -.07517 |
| 65 | -13.55580 | .87517 | -.15125 |
| 66 | -15.98300 | .02167 | -.00194 |
| 67 | -15.98300 | .10817 | -.01073 |
| 68 | -15.98300 | .28041 | -.03242 |
| 69 | -15.98300 | .53684 | -.07517 |
| 70 | -15.98300 | .87517 | -.15125 |

| | | | |
|---|---|---|---|
| 71 | -17.19660 | .02148 | -.00296 |
| 72 | -17.19660 | .10731 | -.01534 |
| 73 | -17.19660 | .27859 | -.04213 |
| 74 | -17.19660 | .53454 | -.08744 |
| 75 | -17.19660 | .87403 | -.15738 |
| 76 | -5.06060 | .02091 | -.00604 |
| 77 | -5.06060 | .10472 | -.02915 |
| 78 | -5.06060 | .27313 | -.07127 |
| 79 | -5.06060 | .52765 | -.12423 |
| 80 | -5.06060 | .87058 | -.17578 |
| 81 | -9.91500 | .02091 | -.00604 |
| 82 | -9.91500 | .10472 | -.02915 |
| 83 | -9.91500 | .27313 | -.07127 |
| 84 | -9.91500 | .52765 | -.12423 |
| 85 | -9.91500 | .87058 | -.17578 |
| 86 | -13.55580 | .02091 | -.00604 |
| 87 | -13.55580 | .10472 | -.02915 |
| 88 | -13.55580 | .27313 | -.07127 |
| 89 | -13.55580 | .52765 | -.12423 |
| 90 | -13.55580 | .87058 | -.17578 |
| 91 | -15.98300 | .02091 | -.00604 |
| 92 | -15.98300 | .10472 | -.02915 |
| 93 | -15.98300 | .27313 | -.07127 |
| 94 | -15.98300 | .52765 | -.12423 |
| 95 | -15.98300 | .87058 | -.17578 |
| 96 | -17.19660 | .0211[illegible] | -.00501 |
| 97 | -17.19660 | .10559 | -.02455 |
| 98 | -17.19660 | .27495 | -.06156 |
| 99 | -17.19660 | .52994 | -.11197 |
| 100 | -17.19660 | .87173 | -.16964 |
| 101 | -.02167 | -5.06060 | -.00194 |
| 102 | -.10817 | -5.06060 | -.01073 |
| 103 | -.28041 | -5.06060 | -.03242 |
| 104 | -.53684 | -5.06060 | -.07517 |
| 105 | -.87517 | -5.06060 | -.15125 |
| 106 | -.02167 | -9.91500 | -.00194 |
| 107 | -.10817 | -9.91500 | -.01073 |
| 108 | -.28041 | -9.91500 | -.03242 |
| 109 | -.53684 | -9.91500 | -.07517 |
| 110 | -.87517 | -9.91500 | -.15125 |
| 111 | -.02167 | -13.55580 | -.00194 |
| 112 | -.10817 | -13.55580 | -.01073 |
| 113 | -.28041 | -13.55580 | -.03242 |
| 114 | -.53684 | -13.55580 | -.07517 |
| 115 | -.87517 | -13.55580 | -.15125 |
| 116 | -.02167 | -15.98300 | -.00194 |
| 117 | -.10817 | -15.98300 | -.01073 |
| 118 | -.28041 | -15.98300 | -.03242 |
| 119 | -.53684 | -15.98300 | -.07517 |
| 120 | -.87517 | -15.98300 | -.15125 |
| 121 | -.02148 | -17.19660 | -.00296 |
| 122 | -.10731 | -17.19660 | -.01534 |
| 123 | -.27859 | -17.19660 | -.04213 |
| 124 | -.53454 | -17.19660 | -.08744 |
| 125 | -.87403 | -17.19660 | -.15738 |
| 126 | -.02091 | -5.06060 | -.00604 |
| 127 | -.10472 | -5.06060 | -.02915 |
| 128 | -.27313 | -5.06060 | -.07127 |
| 129 | -.52765 | -5.06060 | -.12423 |
| 130 | -.87058 | -5.06060 | -.17578 |
| 131 | -.02091 | -9.91500 | -.00604 |
| 132 | -.10472 | -9.91500 | -.02915 |
| 133 | -.27313 | -9.91500 | -.07127 |
| 134 | -.52765 | -9.91500 | -.12423 |
| 135 | -.87058 | -9.91500 | -.17578 |
| 136 | -.02091 | -13.55580 | -.00604 |
| 137 | -.10472 | -13.55580 | -.02915 |
| 138 | -.27313 | -13.55580 | -.07127 |
| 139 | -.52765 | -13.55580 | -.12423 |
| 140 | -.87058 | -13.55580 | -.17578 |
| 141 | -.02091 | -15.98300 | -.00604 |
| 142 | -.10472 | -15.98300 | -.02915 |
| 143 | -.27313 | -15.98300 | -.07127 |

| | | | |
|---|---|---|---|
| 144 | -.52765 | -15.98300 | -.12423 |
| 145 | -.87058 | -15.98300 | -.17578 |
| 146 | -.02110 | -17.19660 | -.00501 |
| 147 | -.10559 | -17.19660 | -.02455 |
| 148 | -.27495 | -17.19660 | -.06156 |
| 149 | -.52994 | -17.19660 | -.11197 |
| 150 | -.87173 | -17.19660 | -.16964 |
| 151 | 5.06060 | -.02167 | -.00194 |
| 152 | 5.06060 | -.10817 | -.01073 |
| 153 | 5.06060 | -.28041 | -.03242 |
| 154 | 5.06060 | -.53684 | -.07517 |
| 155 | 5.06060 | -.87517 | -.15125 |
| 156 | 9.91500 | -.02167 | -.00194 |
| 157 | 9.91500 | -.10817 | -.01073 |
| 158 | 9.91500 | -.28041 | -.03242 |
| 159 | 9.91500 | -.53684 | -.07517 |
| 160 | 9.91500 | -.87517 | -.15125 |
| 161 | 13.55580 | -.02167 | -.00194 |
| 162 | 13.55580 | -.10817 | -.01073 |
| 163 | 13.55580 | -.28041 | -.03242 |
| 164 | 13.55580 | -.53684 | -.07517 |
| 165 | 13.55580 | -.87517 | -.15125 |
| 166 | 15.98300 | -.02167 | -.00194 |
| 167 | 15.98300 | -.10817 | -.01073 |
| 168 | 15.98300 | -.28041 | -.03242 |
| 169 | 15.98300 | -.53684 | -.07517 |
| 170 | 15.98300 | -.87517 | -.15125 |
| 171 | 17.19660 | -.02148 | -.00296 |
| 172 | 17.19660 | -.10731 | -.01534 |
| 173 | 17.19660 | -.27859 | -.04213 |
| 174 | 17.19660 | -.53454 | -.08744 |
| 175 | 17.19660 | -.87403 | -.15738 |
| 176 | 5.06060 | -.02091 | -.00604 |
| 177 | 5.06060 | -.10472 | -.02915 |
| 178 | 5.06060 | -.27313 | -.07127 |
| 179 | 5.06060 | -.52765 | -.12423 |
| 180 | 5.06060 | -.87058 | -.17578 |
| 181 | 9.91500 | -.02091 | -.00604 |
| 182 | 9.91500 | -.10472 | -.02915 |
| 183 | 9.91500 | -.27313 | -.07127 |
| 184 | 9.91500 | -.52765 | -.12423 |
| 185 | 9.91500 | -.87058 | -.17578 |
| 186 | 13.55580 | -.02091 | -.00604 |
| 187 | 13.55580 | -.10472 | -.02915 |
| 188 | 13.55580 | -.27313 | -.07127 |
| 189 | 13.55580 | -.52765 | -.12423 |
| 190 | 13.55580 | -.87058 | -.17578 |
| 191 | 15.98300 | -.02091 | -.00604 |
| 192 | 15.98300 | -.10472 | -.02915 |
| 193 | 15.98300 | -.27313 | -.07127 |
| 194 | 15.98300 | -.52765 | -.12423 |
| 195 | 15.98300 | -.87058 | -.17578 |
| 196 | 17.19660 | -.02110 | -.00501 |
| 197 | 17.19660 | -.10559 | -.02455 |
| 198 | 17.19660 | -.27495 | -.06156 |
| 199 | 17.19660 | -.52994 | -.11197 |
| 200 | 17.19660 | -.87173 | -.16964 |

# Nodal Numbering for Surfaces

FOR SURFACE 24

| | | | | | |
|---|---|---|---|---|---|
| 1 | 7 | 13 | 19 | 25 | 31 |
| 2 | 8 | 14 | 20 | 26 | 32 |
| 3 | 9 | 15 | 21 | 27 | 33 |
| 4 | 10 | 16 | 22 | 28 | 34 |
| 5 | 11 | 17 | 23 | 29 | 35 |
| 6 | 12 | 18 | 24 | 30 | 36 |

FOR SURFACE 25

| | | | | | |
|---|---|---|---|---|---|
| 1 | 7 | 13 | 19 | 25 | 31 |
| 37 | 41 | 45 | 49 | 53 | 32 |
| 38 | 42 | 46 | 50 | 54 | 33 |
| 39 | 43 | 47 | 51 | 55 | 34 |
| 40 | 44 | 48 | 52 | 56 | 35 |
| 6 | 12 | 18 | 24 | 30 | 36 |

FOR SURFACE 27

| | | | | | |
|---|---|---|---|---|---|
| 57 | 63 | 69 | 75 | 81 | 87 |
| 58 | 64 | 70 | 76 | 82 | 88 |
| 59 | 65 | 71 | 77 | 83 | 89 |
| 60 | 66 | 72 | 78 | 84 | 90 |
| 61 | 67 | 73 | 79 | 85 | 91 |
| 62 | 68 | 74 | 80 | 86 | 92 |

FOR SURFACE 28

| | | | | | |
|---|---|---|---|---|---|
| 57 | 63 | 69 | 75 | 81 | 87 |
| 93 | 97 | 101 | 105 | 109 | 88 |
| 94 | 98 | 102 | 106 | 110 | 89 |
| 95 | 99 | 103 | 107 | 111 | 90 |
| 96 | 100 | 104 | 108 | 112 | 91 |
| 62 | 68 | 74 | 80 | 86 | 92 |

FOR SURFACE 30

| | | | | | |
|---|---|---|---|---|---|
| 113 | 119 | 125 | 131 | 137 | 143 |
| 114 | 120 | 126 | 132 | 138 | 144 |
| 115 | 121 | 127 | 133 | 139 | 145 |
| 116 | 122 | 128 | 134 | 140 | 146 |
| 117 | 123 | 129 | 135 | 141 | 147 |
| 118 | 124 | 130 | 136 | 142 | 148 |

FOR SURFACE 31

| | | | | | |
|---|---|---|---|---|---|
| 113 | 119 | 125 | 131 | 137 | 143 |
| 149 | 153 | 157 | 161 | 165 | 144 |
| 150 | 154 | 158 | 162 | 166 | 145 |
| 151 | 155 | 159 | 163 | 167 | 146 |
| 152 | 156 | 160 | 164 | 168 | 147 |
| 118 | 124 | 130 | 136 | 142 | 148 |

FOR SURFACE 33

| | | | | | |
|---|---|---|---|---|---|
| 169 | 175 | 181 | 187 | 193 | 199 |
| 170 | 176 | 182 | 188 | 194 | 200 |
| 171 | 177 | 183 | 189 | 195 | 201 |
| 172 | 178 | 184 | 190 | 196 | 202 |
| 173 | 179 | 185 | 191 | 197 | 203 |
| 174 | 180 | 186 | 192 | 198 | 204 |

FOR SURFACE 34

| | | | | | |
|---|---|---|---|---|---|
| 169 | 175 | 181 | 187 | 193 | 199 |
| 205 | 209 | 213 | 217 | 221 | 200 |
| 206 | 210 | 214 | 218 | 222 | 201 |
| 207 | 211 | 215 | 219 | 223 | 202 |
| 208 | 212 | 216 | 220 | 224 | 203 |
| 174 | 180 | 186 | 192 | 198 | 204 |

## Nodal Numbering for Elements

| ELEM | ++ | +- | -+ | -- |
|---|---|---|---|---|
| 1 | 8 | 2 | 7 | 1 |
| 2 | 9 | 3 | 8 | 2 |
| 3 | 10 | 4 | 9 | 3 |
| 4 | 11 | 5 | 10 | 4 |
| 5 | 12 | 6 | 11 | 5 |
| 6 | 14 | 8 | 13 | 7 |
| 7 | 15 | 9 | 14 | 8 |
| 8 | 16 | 10 | 15 | 9 |
| 9 | 17 | 11 | 16 | 10 |
| 10 | 18 | 12 | 17 | 11 |
| 11 | 20 | 14 | 19 | 13 |
| 12 | 21 | 15 | 20 | 14 |
| 13 | 22 | 16 | 21 | 15 |
| 14 | 23 | 17 | 22 | 16 |
| 15 | 24 | 18 | 23 | 17 |
| 16 | 26 | 20 | 25 | 19 |
| 17 | 27 | 21 | 26 | 20 |
| 18 | 28 | 22 | 27 | 21 |
| 19 | 29 | 23 | 28 | 22 |
| 20 | 30 | 24 | 29 | 23 |
| 21 | 32 | 26 | 31 | 25 |
| 22 | 33 | 27 | 32 | 26 |
| 23 | 34 | 28 | 33 | 27 |
| 24 | 35 | 29 | 34 | 28 |
| 25 | 36 | 30 | 35 | 29 |
| 26 | 37 | 41 | 1 | 7 |
| 27 | 38 | 42 | 37 | 41 |
| 28 | 39 | 43 | 38 | 42 |
| 29 | 40 | 44 | 39 | 43 |
| 30 | 6 | 12 | 40 | 44 |
| 31 | 41 | 45 | 7 | 13 |
| 32 | 42 | 46 | 41 | 45 |
| 33 | 43 | 47 | 42 | 46 |
| 34 | 44 | 48 | 43 | 47 |
| 35 | 12 | 19 | 44 | 48 |
| 36 | 45 | 49 | 13 | 19 |
| 37 | 46 | 50 | 45 | 49 |
| 38 | 47 | 51 | 46 | 50 |
| 39 | 48 | 52 | 47 | 51 |
| 40 | 18 | 24 | 48 | 52 |
| 41 | 49 | 53 | 19 | 25 |
| 42 | 50 | 54 | 49 | 53 |
| 43 | 51 | 55 | 50 | 54 |
| 44 | 52 | 56 | 51 | 55 |
| 45 | 24 | 30 | 52 | 56 |
| 46 | 53 | 32 | 25 | 31 |
| 47 | 54 | 33 | 53 | 32 |
| 48 | 55 | 34 | 54 | 33 |
| 49 | 56 | 35 | 55 | 34 |
| 50 | 30 | 36 | 56 | 35 |
| 51 | 64 | 58 | 63 | 57 |
| 52 | 65 | 59 | 64 | 58 |
| 53 | 66 | 60 | 65 | 59 |
| 54 | 67 | 61 | 66 | 60 |
| 55 | 68 | 62 | 67 | 61 |
| 56 | 70 | 64 | 69 | 63 |
| 57 | 71 | 65 | 70 | 64 |
| 58 | 72 | 66 | 71 | 65 |
| 59 | 73 | 67 | 72 | 66 |
| 60 | 74 | 68 | 73 | 67 |
| 61 | 76 | 70 | 75 | 69 |
| 62 | 77 | 71 | 76 | 70 |
| 63 | 78 | 72 | 77 | 71 |
| 64 | 79 | 73 | 78 | 72 |
| 65 | 80 | 74 | 79 | 73 |
| 66 | 82 | 76 | 81 | 75 |
| 67 | 83 | 77 | 82 | 76 |
| 68 | 84 | 78 | 83 | 77 |

| | | | | |
|---|---|---|---|---|
| 69 | 85 | 79 | 84 | 78 |
| 70 | 86 | 80 | 85 | 79 |
| 71 | 88 | 82 | 87 | 81 |
| 72 | 89 | 83 | 88 | 82 |
| 73 | 90 | 84 | 89 | 83 |
| 74 | 91 | 85 | 90 | 84 |
| 75 | 92 | 86 | 91 | 85 |
| 76 | 93 | 97 | 57 | 63 |
| 77 | 94 | 98 | 93 | 97 |
| 78 | 95 | 99 | 94 | 98 |
| 79 | 96 | 100 | 95 | 99 |
| 80 | 62 | 68 | 96 | 100 |
| 81 | 97 | 101 | 63 | 69 |
| 82 | 98 | 102 | 97 | 101 |
| 83 | 99 | 103 | 98 | 102 |
| 84 | 100 | 104 | 99 | 103 |
| 85 | 68 | 74 | 100 | 104 |
| 86 | 101 | 105 | 69 | 75 |
| 87 | 102 | 106 | 101 | 105 |
| 88 | 103 | 107 | 102 | 106 |
| 89 | 104 | 108 | 103 | 107 |
| 90 | 74 | 80 | 104 | 108 |
| 91 | 105 | 109 | 75 | 81 |
| 92 | 106 | 110 | 105 | 109 |
| 93 | 107 | 111 | 106 | 110 |
| 94 | 108 | 112 | 107 | 111 |
| 95 | 80 | 86 | 108 | 112 |
| 96 | 109 | 88 | 81 | 87 |
| 97 | 110 | 89 | 109 | 88 |
| 98 | 111 | 90 | 110 | 89 |
| 99 | 112 | 91 | 111 | 90 |
| 100 | 86 | 92 | 112 | 91 |
| 101 | 120 | 114 | 119 | 113 |
| 102 | 121 | 115 | 120 | 114 |
| 103 | 122 | 116 | 121 | 115 |
| 104 | 123 | 117 | 122 | 116 |
| 105 | 124 | 118 | 123 | 117 |
| 106 | 126 | 120 | 125 | 119 |
| 107 | 127 | 121 | 126 | 120 |
| 108 | 128 | 122 | 127 | 121 |
| 109 | 129 | 123 | 128 | 122 |
| 110 | 130 | 124 | 129 | 123 |
| 111 | 132 | 126 | 131 | 125 |
| 112 | 133 | 127 | 132 | 126 |
| 113 | 134 | 128 | 133 | 127 |
| 114 | 135 | 129 | 134 | 128 |
| 115 | 136 | 130 | 135 | 129 |
| 116 | 138 | 132 | 137 | 131 |
| 117 | 139 | 133 | 138 | 132 |
| 118 | 140 | 134 | 139 | 133 |
| 119 | 141 | 135 | 140 | 134 |
| 120 | 142 | 136 | 141 | 135 |
| 121 | 144 | 138 | 143 | 137 |
| 122 | 145 | 139 | 144 | 138 |
| 123 | 146 | 140 | 145 | 139 |
| 124 | 147 | 141 | 146 | 140 |
| 125 | 148 | 142 | 147 | 141 |
| 126 | 149 | 153 | 113 | 119 |
| 127 | 150 | 154 | 149 | 153 |
| 128 | 151 | 155 | 130 | 154 |
| 129 | 152 | 156 | 151 | 155 |
| 130 | 118 | 124 | 152 | 156 |
| 131 | 153 | 157 | 119 | 125 |
| 132 | 154 | 158 | 153 | 157 |
| 133 | 155 | 159 | 154 | 158 |
| 134 | 156 | 160 | 155 | 159 |
| 135 | 124 | 130 | 156 | 160 |
| 136 | 157 | 161 | 125 | 131 |
| 137 | 158 | 162 | 157 | 161 |
| 138 | 159 | 163 | 158 | 162 |
| 139 | 160 | 164 | 159 | 163 |
| 140 | 130 | 136 | 160 | 164 |
| 141 | 161 | 165 | 131 | 137 |

| | | | | |
|---|---|---|---|---|
| 142 | 162 | 166 | 161 | 165 |
| 143 | 163 | 167 | 162 | 166 |
| 144 | 164 | 168 | 163 | 167 |
| 145 | 136 | 142 | 164 | 168 |
| 146 | 165 | 144 | 137 | 143 |
| 147 | 166 | 145 | 165 | 144 |
| 148 | 167 | 146 | 166 | 145 |
| 149 | 168 | 147 | 167 | 146 |
| 150 | 142 | 148 | 168 | 147 |
| 151 | 176 | 170 | 175 | 169 |
| 152 | 177 | 171 | 176 | 170 |
| 153 | 178 | 172 | 177 | 171 |
| 154 | 179 | 173 | 178 | 172 |
| 155 | 180 | 174 | 179 | 173 |
| 156 | 182 | 176 | 181 | 175 |
| 157 | 183 | 177 | 182 | 176 |
| 158 | 184 | 178 | 183 | 177 |
| 159 | 185 | 179 | 184 | 178 |
| 160 | 186 | 180 | 185 | 179 |
| 161 | 188 | 182 | 187 | 181 |
| 162 | 189 | 183 | 188 | 182 |
| 163 | 190 | 184 | 189 | 183 |
| 164 | 191 | 185 | 190 | 184 |
| 165 | 192 | 186 | 191 | 185 |
| 166 | 194 | 188 | 193 | 187 |
| 167 | 195 | 189 | 194 | 188 |
| 168 | 196 | 190 | 195 | 189 |
| 169 | 197 | 191 | 196 | 190 |
| 170 | 198 | 192 | 197 | 191 |
| 171 | 200 | 194 | 199 | 193 |
| 172 | 201 | 195 | 200 | 194 |
| 173 | 202 | 196 | 201 | 195 |
| 174 | 203 | 197 | 202 | 196 |
| 175 | 204 | 198 | 203 | 197 |
| 176 | 205 | 209 | 169 | 175 |
| 177 | 206 | 210 | 205 | 209 |
| 178 | 207 | 211 | 206 | 210 |
| 179 | 208 | 212 | 207 | 211 |
| 180 | 174 | 180 | 208 | 212 |
| 181 | 209 | 213 | 175 | 181 |
| 182 | 210 | 214 | 209 | 213 |
| 183 | 211 | 215 | 210 | 214 |
| 184 | 212 | 216 | 211 | 215 |
| 185 | 180 | 186 | 212 | 216 |
| 186 | 213 | 217 | 181 | 187 |
| 187 | 214 | 218 | 213 | 217 |
| 188 | 215 | 219 | 214 | 218 |
| 189 | 216 | 220 | 215 | 219 |
| 190 | 186 | 192 | 216 | 220 |
| 191 | 217 | 221 | 187 | 193 |
| 192 | 218 | 222 | 217 | 221 |
| 193 | 219 | 223 | 218 | 222 |
| 194 | 220 | 224 | 219 | 223 |
| 195 | 192 | 198 | 220 | 224 |
| 196 | 221 | 200 | 193 | 199 |
| 197 | 222 | 201 | 221 | 200 |
| 198 | 223 | 202 | 222 | 201 |
| 199 | 224 | 203 | 223 | 202 |
| 200 | 198 | 204 | 224 | 203 |

## The Distribution of the Source

FOR SUBSURFACE 24

| | | | | |
|---|---|---|---|---|
| -.67898E+01 | -.12965E+02 | -.17601E+02 | -.20237E+02 | -.11351E+02 |
| -.64984E+01 | -.12450E+02 | -.16917E+02 | -.19516E+02 | -.10964E+02 |
| -.36705E+01 | -.69826E+01 | -.94592E+01 | -.10879E+02 | -.62031E+01 |
| .20676E+01 | .40148E+01 | .54635E+01 | .63976E+01 | .33652E+01 |
| .76145E+01 | .14806E+02 | .20137E+02 | .23241E+02 | .12750E+02 |

FOR SUBSURFACE 25

| | | | | |
|---|---|---|---|---|
| -.70504E+01 | -.13521E+02 | -.18387E+02 | -.21175E+02 | -.11844E+02 |
| -.75670E+01 | -.14784E+02 | -.20220E+02 | -.23463E+02 | -.13102E+02 |
| -.59701E+01 | -.11792E+02 | -.16203E+02 | -.18950E+02 | -.10664E+02 |
| -.85895E+00 | -.20238E+01 | -.29820E+01 | -.37337E+01 | -.22639E+01 |
| .60343E+01 | .11586E+02 | .15663E+02 | .17933E+02 | .98657E+01 |

FOR SUBSURFACE 27

| | | | | |
|---|---|---|---|---|
| -.67898E+01 | -.12965E+02 | -.17601E+02 | -.20237E+02 | -.11351E+02 |
| -.64984E+01 | -.12450E+02 | -.16917E+02 | -.19516E+02 | -.10964E+02 |
| -.36705E+01 | -.69826E+01 | -.94592E+01 | -.10879E+02 | -.62031E+01 |
| .20676E+01 | .40148E+01 | .54635E+01 | .63976E+01 | .33652E+01 |
| .76145E+01 | .14806E+02 | .20137E+02 | .23241E+02 | .12750E+02 |

FOR SUBSURFACE 28

| | | | | |
|---|---|---|---|---|
| -.70504E+01 | -.13521E+02 | -.18387E+02 | -.21175E+02 | -.11844E+02 |
| -.75670E+01 | -.14784E+02 | -.20220E+02 | -.23463E+02 | -.13102E+02 |
| -.59701E+01 | -.11792E+02 | -.16203E+02 | -.18950E+02 | -.10664E+02 |
| -.85895E+00 | -.20238E+01 | -.29820E+01 | -.37337E+01 | -.22639E+01 |
| .60343E+01 | .11586E+02 | .15663E+02 | .17933E+02 | .98657E+01 |

FOR SUBSURFACE 30

| | | | | |
|---|---|---|---|---|
| -.67898E+01 | -.12965E+02 | -.17601E+02 | -.20237E+02 | -.11351E+02 |
| -.64984E+01 | -.12450E+02 | -.16917E+02 | -.19516E+02 | -.10964E+02 |
| -.36705E+01 | -.69326E+01 | -.94592E+01 | -.10879E+02 | -.62031E+01 |
| .20676E+01 | .40148E+01 | .54635E+01 | .63976E+01 | .33652E+01 |
| .76145E+01 | .14806E+02 | .20137E+02 | .23241E+02 | .12750E+02 |

FOR SUBSURFACE 31

| | | | | |
|---|---|---|---|---|
| -.70504E+01 | -.13521E+02 | -.18387E+02 | -.21175E+02 | -.11844E+02 |
| -.75670E+01 | -.14784E+02 | -.20220E+02 | -.23463E+02 | -.13102E+02 |
| -.59701E+01 | -.11792E+02 | -.16203E+02 | -.18950E+02 | -.10664E+02 |
| -.85895E+00 | -.20238E+01 | -.29820E+01 | -.37337E+01 | -.22639E+01 |
| .60343E+01 | .11586E+02 | .15663E+02 | .17933E+02 | .98657E+01 |

FOR SUBSURFACE 33

| | | | | |
|---|---|---|---|---|
| -.67898E+01 | -.12965E+02 | -.17601E+02 | -.20237E+02 | -.11351E+02 |
| -.64984E+01 | -.12450E+02 | -.16917E+02 | -.19516E+02 | -.10964E+02 |
| -.36705E+01 | -.69326E+01 | -.94592E+01 | -.10879E+02 | -.62031E+01 |
| .20676E+01 | .40148E+01 | .54635E+01 | .63976E+01 | .33652E+01 |
| .76145E+01 | .14806E+02 | .20137E+02 | .23241E+02 | .12750E+02 |

FOR SUBSURFACE 34

| | | | | |
|---|---|---|---|---|
| -.70504E+01 | -.13521E+02 | -.18387E+02 | -.21175E+02 | -.11844E+02 |
| -.75670E+01 | -.14784E+02 | -.20220E+02 | -.23463E+02 | -.13102E+02 |
| -.59701E+01 | -.11792E+02 | -.16203E+02 | -.18950E+02 | -.10664E+02 |
| -.85895E+00 | -.20238E+01 | -.29820E+01 | -.37337E+01 | -.22639E+01 |
| .60343E+01 | .11586E+02 | .15663E+02 | .17933E+02 | .98657E+01 |

## The Distribution of the Velocity Potential

FOR SUBSURFACE 24

| | | | | |
|---|---|---|---|---|
| .17602E+03 | .20640E+03 | .20732E+03 | .18068E+03 | .15468E+03 |
| .17886E+03 | .21339E+03 | .21798E+03 | .19379E+03 | .16714E+03 |
| .18380E+03 | .22322E+03 | .23153E+03 | .20961E+03 | .17963E+03 |
| .18929E+03 | .23356E+03 | .24566E+03 | .22568E+03 | .18934E+03 |
| .18643E+03 | .23073E+03 | .24566E+03 | .22257E+03 | .18346E+03 |

FOR SUBSURFACE 25

| | | | | |
|---|---|---|---|---|
| .16041E+03 | .17883E+03 | .17098E+03 | .13619E+03 | .11212E+03 |
| .15183E+03 | .16619E+03 | .15586E+03 | .11874E+03 | .95400E+02 |
| .14552E+03 | .15728E+03 | .14563E+03 | .10694E+03 | .82754E+02 |
| .14380E+03 | .15562E+03 | .14404E+03 | .10571E+03 | .78885E+02 |
| .14135E+03 | .15756E+03 | .14451E+03 | .10988E+03 | .82064E+02 |

FOR SUBSURFACE 27

| | | | | |
|---|---|---|---|---|
| .17602E+03 | .20640E+03 | .20732E+03 | .18068E+03 | .15468E+03 |
| .17886E+03 | .21339E+03 | .21798E+03 | .19379E+03 | .16714E+03 |
| .18380E+03 | .22322E+03 | .23153E+03 | .20961E+03 | .17963E+03 |
| .18929E+03 | .23356E+03 | .24566E+03 | .22568E+03 | .18934E+03 |
| .18643E+03 | .23073E+03 | .24566E+03 | .22257E+03 | .18346E+03 |

FOR SUBSURFACE 28

| | | | | |
|---|---|---|---|---|
| .16041E+03 | .17883E+03 | .17098E+03 | .13619E+03 | .11212E+03 |
| .15183E+03 | .16619E+03 | .15586E+03 | .11874E+03 | .95400E+02 |
| .14552E+03 | .15728E+03 | .14563E+03 | .10694E+03 | .82754E+02 |
| .14380E+03 | .15562E+03 | .14404E+03 | .10571E+03 | .78885E+02 |
| .14135E+03 | .15756E+03 | .14451E+03 | .10988E+03 | .82064E+02 |

FOR SUBSURFACE 30

| | | | | |
|---|---|---|---|---|
| .17602E+03 | .20640E+03 | .20732E+03 | .18068E+03 | .15468E+03 |
| .17886E+03 | .21339E+03 | .21798E+03 | .19379E+03 | .16714E+03 |
| .18380E+03 | .22322E+03 | .23153E+03 | .20961E+03 | .17963E+03 |
| .18929E+03 | .23356E+03 | .24566E+03 | .22568E+03 | .18934E+03 |
| .18643E+03 | .23073E+03 | .24566E+03 | .22257E+03 | .18346E+03 |

FOR SUBSURFACE 31

| | | | | |
|---|---|---|---|---|
| .16041E+03 | .17883E+03 | .17098E+03 | .13619E+03 | .11212E+03 |
| .15183E+03 | .16619E+03 | .15586E+03 | .11874E+03 | .95400E+02 |
| .14552E+03 | .15728E+03 | .14563E+03 | .10694E+03 | .82754E+02 |
| .14360E+03 | .15562E+03 | .14404E+03 | .10571E+03 | .78685E+02 |
| .14135E+03 | .15756E+03 | .14451E+03 | .10988E+03 | .82064E+02 |

FOR SUBSURFACE 33

| | | | | |
|---|---|---|---|---|
| .17602E+03 | .20540E+03 | .20732E+03 | .18068E+03 | .15468E+03 |
| .17886E+03 | .21339E+03 | .21798E+03 | .19379E+03 | .16714E+03 |
| .18380E+03 | .22322E+03 | .23153E+03 | .20961E+03 | .17963E+03 |
| .18929E+03 | .23356E+03 | .24566E+03 | .22568E+03 | .18934E+03 |
| .18643E+03 | .23073E+03 | .24566E+03 | .22257E+03 | .18346E+03 |

FOR SUBSURFACE 34

| | | | | |
|---|---|---|---|---|
| .16041E+03 | .17883E+03 | .17098E+03 | .13619E+03 | .11212E+03 |
| .15183E+03 | .16619E+03 | .15586E+03 | .11874E+03 | .95408E+02 |
| .14552E+03 | .15728E+03 | .14563E+03 | .10694E+03 | .82754E+02 |
| .14360E+03 | .15562E+03 | .14404E+03 | .10571E+03 | .78685E+02 |
| .14135E+03 | .15756E+03 | .14451E+03 | .10988E+03 | .82064E+02 |

## Pressure Distribution

FOR SUBSURFACE 24

| | | | | |
|---|---|---|---|---|
| -.10193E+01 | -.18540E+01 | -.29055E+01 | -.36553E+01 | -.18860E+01 |
| -.15173E+00 | -.30130E+00 | -.48997E+00 | -.60060E+00 | -.28944E+00 |
| -.11633E+00 | -.21550E+00 | -.33475E+00 | -.38244E+00 | -.21574E+00 |
| -.24355E-01 | -.61409E-01 | -.10785E+00 | -.10601E+00 | -.65347E-01 |
| .27068E+00 | .45045E+00 | .66623E+00 | .79997E+00 | .41744E+00 |

FOR SUBSURFACE 25

| | | | | |
|---|---|---|---|---|
| .12332E+01 | .20739E+01 | .30870E+01 | .38080E+01 | .21446E+01 |
| .24285E+00 | .37140E+00 | .51221E+00 | .61583E+00 | .35977E+00 |
| .77155E-01 | .11078E+00 | .14419E+00 | .17862E+00 | .82484E-01 |
| .19756E-01 | .92368E-02 | -.29301E-02 | -.11323E-01 | -.10274E-01 |
| -.25524E+00 | -.45014E+00 | -.68576E+00 | -.82448E+00 | -.41975E+00 |

FOR SUBSURFACE 27

| | | | | |
|---|---|---|---|---|
| -.22063E+00 | -.66035E+00 | -.12827E+01 | -.17903E+01 | -.10721E+01 |
| -.24219E-01 | -.94383E-01 | -.22389E+00 | -.33037E+00 | -.39245E+00 |
| -.14865E-01 | -.60488E-01 | -.15311E+00 | -.22746E+00 | -.42499E+00 |
| .69449E-02 | -.19458E-02 | -.51913E-01 | -.99233E-01 | -.39249E+00 |
| .71613E-01 | .17953E+00 | .28145E+00 | .32919E+00 | -.22828E-01 |

FOR SUBSURFACE 28

| | | | | |
|---|---|---|---|---|
| .28237E+00 | .75515E+00 | .13274E+01 | .17690E+01 | .10734E+01 |
| .58637E-01 | .13832E+00 | .19970E+00 | .24258E+00 | .29758E+00 |
| .20845E-01 | .40475E-01 | .37636E-01 | .31767E-01 | .21774E+00 |
| .81468E-02 | .36365E-02 | -.26761E-01 | -.60218E-01 | .19615E+00 |
| -.50783E-01 | -.15666E+00 | -.31931E+00 | -.44820E+00 | -.14959E+00 |

FOR SUBSURFACE 30

| | | | | |
|---|---|---|---|---|
| .56203E+00 | .51296E+00 | .36899E+00 | .16555E+00 | .16322E-01 |
| .03755E-01 | .83474E-01 | .62159E-01 | .26930E-01 | .99553E-03 |
| .64417E-01 | .59976E-01 | .42390E-01 | .16581E-01 | -.31805E-02 |
| .14005E-01 | .17769E-01 | .13533E-01 | .32679E-02 | -.10356E-01 |
| -.14844E+00 | -.12360E+00 | -.85126E-01 | -.38927E-01 | -.14940E-01 |

FOR SUBSURFACE 31

| | | | | |
|---|---|---|---|---|
| -.67996E+00 | -.57377E+00 | -.39208E+00 | -.17259E+00 | -.18741E-01 |
| -.13386E+00 | -.10274E+00 | -.65213E-01 | -.28222E-01 | -.24223E-02 |
| -.42457E-01 | -.30642E-01 | -.18754E-01 | -.89582E-02 | .20596E-02 |
| -.10723E-01 | -.25429E-02 | -.47929E-03 | -.11878E-02 | .61449E-02 |
| .14121E+00 | .12492E+00 | .86005E-01 | .34585E-01 | .65353E-02 |

FOR SUBSURFACE 33

| | | | | |
|---|---|---|---|---|
| -.23663E+00 | -.68066E+00 | -.12539E+01 | -.16995E+01 | -.79758E+00 |
| -.43758E-01 | -.12314E+00 | -.20396E+00 | -.24330E+00 | .10400E+00 |
| -.37047E-01 | -.95035E-01 | -.13926E+00 | -.13840E+00 | .20607E+00 |
| -.17294E-01 | -.41695E-01 | -.42407E-01 | -.35046E-02 | .31679E+00 |
| .50638E-01 | .14732E+00 | .29965E+00 | .43185E+00 | .42533E+00 |

FOR SUBSURFACE 34

| | | | | |
|---|---|---|---|---|
| .27089E+00 | .74493E+00 | .13675E+01 | .18664E+01 | .10525E+01 |
| .50350E-01 | .13253E+00 | .24729E+00 | .34503E+00 | .59768E-01 |
| .13853E-01 | .39664E-01 | .87800E-01 | .13789E+00 | -.13319E+00 |
| .88585E-03 | .30078E-02 | .23352E-01 | .47707E-01 | -.20028E+00 |
| -.63241E-01 | -.16356E+00 | -.28045E+00 | -.34170E+00 | -.26362E+00 |

## SAMPLE CASE 3:

## BO-105 FUSELAGE (NO PYLON, NO ROTOR) WITH EFFECTS OF SEPARATION

### Data Input

```
  3
PROGRAM SHAPES
HUB PYLON FLOW SEPARATION
FUSELAGE - WITH SEPARATION EFFECTS
KREAD      0
*         12      0      0
**         0      1      1      1      0      0      0      0      0
***        0      0
UAMCH         .204        0.000        -0.000
ALFA         0.000        0.000
NBODY        0.000       12.000        38.000       41.000
NBODY        0.000        0.000         0.000        0.000
NBODY        0.000        0.000         0.000        0.000
NBODY        7.250        8.250         7.250        8.250
NWAKE      1      0      0      0
NPYLON     1      1
CSTAG     -20.000         1.000
KPRINT     1      1      1      1      0      1      1      1      1      1
NBODY1     4      4      2      1      1
NBODY2     4      4      1      1      1
NBODY3     4      4      2      1      1
```

## Specifications of the Problem

```
FOR PART   1
NX= 4
NY= 4

FOR PART   2
NX= 4
NY= 4

FOR PART   3
NX= 4
NY= 4

FOR PART   5
NX= 4
NY= 4

FOR PART   6
NX= 4
NY= 4

FOR PART   7
NX= 4
NY= 4

FOR PART   9
NX= 4
NY= 4

FOR PART  10
NX= 4
NY= 4

FOR PART  11
NX= 4
NY= 4

FOR PART  13
NX= 4
NY= 4

FOR PART  14
NX= 4
NY= 4

FOR PART  15
NX= 4
NY= 4

NELEM=192

KSYMMY= 0
KSYMMZ= 0
```

## X, Y, and Z Coordinates of the Nodes

| NODE= | X | Y | Z |
|---|---|---|---|
| 1 | 0.00000 | 0.00000 | 0.00000 |
| 2 | .75000 | -.00000 | 2.06250 |
| 3 | 3.00000 | -.00000 | 4.12500 |
| 4 | 6.75000 | -.00000 | 6.18750 |
| 5 | 12.00000 | .00000 | 8.25000 |
| 6 | .75000 | .59351 | 1.90550 |
| 7 | 3.00000 | 1.36723 | 3.81100 |
| 8 | 6.75000 | 2.08084 | 5.71650 |
| 9 | 12.00000 | 2.77445 | 7.62201 |
| 10 | .75000 | 1.29153 | 1.45841 |
| 11 | 3.00000 | 2.58326 | 2.91682 |
| 12 | 6.75000 | 3.84469 | 4.37522 |
| 13 | 12.00000 | 5.12652 | 5.83363 |
| 14 | .75000 | 1.57453 | .78923 |
| 15 | 3.00000 | 3.34906 | 1.57857 |
| 16 | 6.75000 | 5.02359 | 2.36785 |
| 17 | 12.00000 | 6.59813 | 3.15714 |
| 18 | .75000 | 1.81250 | 0.00000 |
| 19 | 3.00000 | 3.62500 | 0.00000 |
| 20 | 6.75000 | 5.43750 | 0.00000 |
| 21 | 12.00000 | 7.25000 | 0.00000 |
| 22 | 18.50000 | -.00000 | 8.25000 |
| 23 | 25.00000 | -.00000 | 8.25000 |
| 24 | 31.50000 | -.00000 | 8.25000 |
| 25 | 38.00000 | .00000 | 8.25000 |
| 26 | 18.50000 | 2.77445 | 7.62201 |
| 27 | 25.00000 | 2.77445 | 7.62201 |
| 28 | 31.50000 | 2.77445 | 7.62201 |
| 29 | 38.00000 | 2.77445 | 7.62201 |
| 30 | 18.50000 | 5.12652 | 5.83363 |
| 31 | 25.00000 | 5.12652 | 5.83363 |
| 32 | 31.50000 | 5.12652 | 5.83363 |
| 33 | 38.00000 | 5.12652 | 5.83363 |
| 34 | 18.50000 | 6.59813 | 3.15714 |
| 35 | 25.00000 | 6.59813 | 3.15714 |
| 36 | 31.50000 | 6.59813 | 3.15714 |
| 37 | 38.00000 | 6.59813 | 3.15714 |
| 38 | 18.50000 | 7.25000 | 0.00000 |
| 39 | 25.00000 | 7.25000 | 0.00000 |
| 40 | 31.50000 | 7.25000 | 0.00000 |
| 41 | 38.00000 | 7.25000 | 0.00000 |
| 42 | 39.31250 | -.00000 | 6.18750 |
| 43 | 40.25000 | -.00000 | 4.12500 |
| 44 | 40.81250 | -.00000 | 2.06250 |
| 45 | 41.00000 | 0.00000 | 0.00000 |
| 46 | 39.31250 | 2.08084 | 5.71650 |
| 47 | 40.25000 | 1.36723 | 3.81100 |
| 48 | 40.81250 | .59351 | 1.90550 |
| 49 | 39.31250 | 3.84469 | 4.37522 |
| 50 | 40.25000 | 2.58326 | 2.91682 |
| 51 | 40.81250 | 1.29153 | 1.45841 |
| 52 | 39.31250 | 5.02359 | 2.36785 |
| 53 | 40.25000 | 3.34906 | 1.57857 |
| 54 | 40.81250 | 1.57453 | .78928 |
| 55 | 39.31250 | 5.43750 | 0.00000 |
| 56 | 40.25000 | 3.62500 | 0.00000 |
| 57 | 40.81250 | 1.81250 | 0.00000 |
| 58 | .75000 | -.00000 | -2.06250 |
| 59 | 3.00000 | -.00000 | -4.12500 |
| 60 | 6.75000 | -.00000 | -6.18750 |
| 61 | 12.00000 | .00000 | -8.25000 |
| 62 | .75000 | .59351 | -1.90550 |
| 63 | 3.00000 | 1.36723 | -3.81100 |
| 64 | 6.75000 | 2.08084 | -5.71650 |
| 65 | 12.00000 | 2.77445 | -7.62201 |
| 66 | .75000 | 1.29153 | -1.45841 |
| 67 | 3.00000 | 2.58326 | -2.91682 |
| 68 | 6.75000 | 3.84469 | -4.37522 |

| | | | |
|---|---|---|---|
| 69 | 12.00000 | 5.12552 | -5.83363 |
| 70 | .75000 | 1.57453 | -.78928 |
| 71 | 3.00000 | 3.34906 | -1.57857 |
| 72 | 6.75000 | 5.02359 | -2.36785 |
| 73 | 12.00000 | 6.69813 | -3.15714 |
| 74 | 18.50000 | -.00000 | -8.25000 |
| 75 | 25.[illegible] | -.0[illegible] | -8.25[illegible] |
| 76 | 31.50000 | -.00000 | -8.25000 |
| 77 | 38.00000 | .00000 | -8.25000 |
| 78 | 18.50000 | 2.77445 | -7.62201 |
| 79 | 25.00000 | 2.77445 | -7.622[illegible] |
| 80 | 31.50000 | 2.77445 | -7.62201 |
| 81 | 38.00000 | 2.77445 | -7.62201 |
| 82 | 18.50000 | 5.12552 | -5.83363 |
| 83 | 25.00000 | 5.12552 | -5.83363 |
| 84 | 31.5[illegible] | 5.12552 | -5.83363 |
| 85 | 38.00000 | 5.12552 | -5.83363 |
| 86 | 18.50000 | 6.69813 | -3.15714 |
| 87 | 25.00000 | 6.69813 | -3.15714 |
| 88 | 31.50000 | 6.69813 | -3.15714 |
| 89 | 38.00000 | 6.69813 | -3.15714 |
| 90 | 39.31250 | -.00000 | -6.18750 |
| 91 | 40.25000 | -.00000 | -4.12500 |
| 92 | 40.81250 | -.00000 | -2.06250 |
| 93 | 39.31250 | 2.08084 | -5.71650 |
| 94 | 40.25000 | 1.38723 | -3.81100 |
| 95 | 40.81250 | .69361 | -1.90550 |
| 96 | 39.31250 | 3.34489 | -4.37522 |
| 97 | 40.25000 | 2.56326 | -2.91682 |
| 98 | 40.81250 | 1.28163 | -1.45841 |
| 99 | 39.31250 | 5.02359 | -2.36785 |
| 100 | 40.25000 | 3.34906 | -1.57857 |
| 101 | 40.81250 | 1.67453 | -.78928 |
| 102 | .75000 | -.69361 | 1.90550 |
| 103 | 3.00000 | -1.38723 | 3.81100 |
| 104 | 6.75000 | -2.08084 | 5.71650 |
| 105 | 12.00000 | -2.77445 | 7.62201 |
| 106 | .75000 | -1.28163 | 1.45841 |
| 107 | 3.00000 | -2.56326 | 2.91682 |
| 108 | 6.75000 | -3.84489 | 4.37522 |
| 109 | 12.00000 | -5.12652 | 5.83363 |
| 110 | .75000 | -1.67453 | .78928 |
| 111 | 3.00000 | -3.34906 | 1.57857 |
| 112 | 6.75000 | -5.02359 | 2.36785 |
| 113 | 12.00000 | -6.69813 | 3.15714 |
| 114 | .75000 | -1.81250 | 0.00000 |
| 115 | 3.00000 | -3.62500 | 0.00000 |
| 116 | 6.75000 | -5.43750 | 0.00000 |
| 117 | 12.[illegible] | -7.25000 | 0.00000 |
| 118 | 18.50000 | -2.77445 | 7.62201 |
| 119 | 25.00000 | -2.77445 | 7.62201 |
| 120 | 31.50000 | -2.77445 | 7.62201 |
| 121 | 38.00000 | -2.77445 | 7.62201 |
| 122 | 18.5[illegible] | -5.12552 | 5.83363 |
| 123 | 25.00000 | -5.12652 | 5.83363 |
| 124 | 31.50000 | -5.12652 | 5.83363 |
| 125 | 38.00000 | -5.12552 | 5.83363 |
| 126 | 18.50000 | -6.69813 | 3.15714 |
| 127 | 25.00000 | -6.69813 | 3.15714 |
| 128 | 31.50000 | -6.69813 | 3.15714 |
| 129 | 38.00000 | -6.69813 | 3.15714 |
| 130 | 18.50000 | -7.25000 | 0.00000 |
| 131 | 25.[illegible] | -7.25[illegible] | 0.00000 |
| 132 | 31.50000 | -7.25000 | 0.00000 |
| 133 | 38.00000 | -7.25000 | 0.00000 |
| 134 | 39.31250 | -2.08084 | 5.71650 |
| 135 | 40.25000 | -1.38723 | 3.81100 |
| 136 | 40.81250 | -.69361 | 1.90550 |
| 137 | 39.31250 | -3.84489 | 4.37522 |
| 138 | 40.25000 | -2.56326 | 2.91682 |
| 139 | 40.81250 | -1.28163 | 1.45841 |
| 140 | 39.31250 | -5.02359 | 2.36785 |

| | | | |
|---|---|---|---|
| 141 | 40.25000 | -3.34906 | 1.57657 |
| 142 | 40.81250 | -1.57453 | .78928 |
| 143 | 39.31250 | -5.43750 | 0.00000 |
| 144 | 40.25000 | -3.52500 | 0.00000 |
| 145 | 40.81250 | -1.31250 | 0.00000 |
| 146 | .75000 | -.59361 | -1.90550 |
| 147 | 3.00000 | -1.38723 | -3.81100 |
| 148 | 6.75000 | -2.08034 | -5.71650 |
| 149 | 12.00000 | -2.77445 | -7.62201 |
| 150 | .75000 | -1.25163 | -1.45841 |
| 151 | 3.00000 | -2.55326 | -2.91682 |
| 152 | 6.75000 | -3.84489 | -4.37522 |
| 153 | 12.00000 | -5.12652 | -5.83363 |
| 154 | .75000 | -1.57453 | -.78928 |
| 155 | 3.00000 | -3.34906 | -1.57657 |
| 156 | 6.75000 | -5.02359 | -2.36485 |
| 157 | 12.00000 | -6.69813 | -3.15714 |
| 158 | 18.50000 | -2.77445 | -7.62201 |
| 159 | 25.00000 | -2.77445 | -7.62201 |
| 160 | 31.50000 | -2.77445 | -7.62201 |
| 161 | 38.00000 | -2.77445 | -7.62201 |
| 162 | 18.50000 | -5.12652 | -5.83363 |
| 163 | 25.00000 | -5.12652 | -5.83363 |
| 164 | 31.50000 | -5.12652 | -5.83363 |
| 165 | 38.00000 | -5.12652 | -5.83363 |
| 166 | 18.50000 | -6.69813 | -3.15714 |
| 167 | 25.00000 | -6.69813 | -3.15714 |
| 168 | 31.50000 | -6.69813 | -3.15714 |
| 169 | 38.00000 | -6.69813 | -3.15714 |
| 170 | 39.31250 | -2.08034 | -5.71650 |
| 171 | 40.25000 | -1.38723 | -3.81100 |
| 172 | 40.81250 | -.59361 | -1.90550 |
| 173 | 39.31250 | -3.84489 | -4.37522 |
| 174 | 40.25000 | -2.55326 | -2.91682 |
| 175 | 40.81250 | -1.25163 | -1.45841 |
| 176 | 39.31250 | -5.02359 | -2.36485 |
| 177 | 40.25000 | -3.34906 | -1.57657 |
| 178 | 40.81250 | -1.57453 | -.78928 |

## X, Y, and Z Coordinates of the Centroid of Aerodynamic Panels

| ELEM= | XPC | YPC | ZPC |
|---|---|---|---|
| 1 | .38306 | .17340 | .99200 |
| 2 | 1.91528 | .52021 | 2.97600 |
| 3 | 4.97972 | .85702 | 4.96000 |
| 4 | 9.57638 | 1.21392 | 5.94400 |
| 5 | .38306 | .49381 | .84098 |
| 6 | 1.91528 | 1.48143 | 2.52293 |
| 7 | 4.97972 | 2.46905 | 4.20489 |
| 8 | 9.57638 | 3.44658 | 5.38664 |
| 9 | .38306 | .73924 | .56192 |
| 10 | 1.91528 | 2.21712 | 1.66577 |
| 11 | 4.97972 | 3.69520 | 2.80952 |
| 12 | 9.57638 | 5.17325 | 3.93365 |
| 13 | .38306 | .87175 | .19732 |
| 14 | 1.91528 | 2.61527 | .59196 |
| 15 | 4.97972 | 4.35879 | .98661 |
| 16 | 9.57638 | 6.10231 | 1.38125 |
| 17 | 15.57758 | 1.38723 | 7.93600 |
| 18 | 22.21721 | 1.38723 | 7.93600 |
| 19 | 28.85683 | 1.38723 | 7.93600 |
| 20 | 35.49646 | 1.38723 | 7.93600 |
| 21 | 15.57758 | 3.95049 | 6.72782 |
| 22 | 22.21721 | 3.95049 | 6.72782 |
| 23 | 28.85683 | 3.95049 | 6.72782 |
| 24 | 35.49646 | 3.95049 | 6.72782 |
| 25 | 15.57758 | 5.91233 | 4.49539 |
| 26 | 22.21721 | 5.91233 | 4.49539 |
| 27 | 28.85683 | 5.91233 | 4.49539 |
| 28 | 35.49646 | 5.91233 | 4.49538 |
| 29 | 15.57758 | 6.97406 | 1.57857 |
| 30 | 22.21721 | 6.97406 | 1.57857 |
| 31 | 28.85683 | 6.97406 | 1.57857 |
| 32 | 35.49646 | 6.97406 | 1.57857 |
| 33 | 39.48662 | 1.21392 | 5.94400 |
| 34 | 40.63578 | .85702 | 4.96000 |
| 35 | 41.40190 | .52021 | 2.97600 |
| 36 | 41.78495 | .17340 | .99200 |
| 37 | 39.48662 | 3.44658 | 5.38664 |
| 38 | 40.63578 | 2.46905 | 4.20489 |
| 39 | 41.40190 | 1.48143 | 2.52293 |
| 40 | 41.78495 | .49381 | .84098 |
| 41 | 39.48662 | 5.17325 | 3.93365 |
| 42 | 40.63578 | 3.69520 | 2.80952 |
| 43 | 41.40190 | 2.21712 | 1.66577 |
| 44 | 41.78495 | .73924 | .56192 |
| 45 | 39.48662 | 6.10231 | 1.38125 |
| 46 | 40.63578 | 4.35879 | .98661 |
| 47 | 41.40190 | 2.61527 | .59196 |
| 48 | 41.78495 | .87175 | .19732 |
| 49 | .38306 | .17340 | -.99200 |
| 50 | 1.91528 | .52021 | -2.97600 |
| 51 | 4.97972 | .85702 | -4.95000 |
| 52 | 9.57638 | 1.21392 | -5.94400 |
| 53 | .38306 | .49381 | -.84098 |
| 54 | 1.91528 | 1.48143 | -2.52293 |
| 55 | 4.97972 | 2.46905 | -4.20489 |
| 56 | 9.57638 | 3.44658 | -5.38664 |
| 57 | .38306 | .73924 | -.56192 |
| 58 | 1.91528 | 2.21712 | -1.66577 |
| 59 | 4.97972 | 3.69520 | -2.80952 |
| 60 | 9.57638 | 5.17325 | -3.93365 |
| 61 | .38306 | .87175 | -.19732 |
| 62 | 1.91528 | 2.61527 | -.59196 |
| 63 | 4.97972 | 4.35879 | -.98661 |
| 64 | 9.57638 | 6.10231 | -1.38125 |

| | | | |
|---|---|---|---|
| 65 | 15.57758 | 1.38723 | -7.93600 |
| 66 | 22.21721 | 1.38723 | -7.93600 |
| 67 | 28.85683 | 1.38723 | -7.93600 |
| 68 | 35.49646 | 1.38723 | -7.93600 |
| 69 | 15.57758 | 3.95049 | -6.72782 |
| 70 | 22.21721 | 3.95049 | -6.72782 |
| 71 | 28.85683 | 3.95049 | -6.72782 |
| 72 | 35.49646 | 3.95049 | -6.72782 |
| 73 | 15.57758 | 5.31233 | -4.49538 |
| 74 | 22.21721 | 5.31233 | -4.49538 |
| 75 | 28.85683 | 5.31233 | -4.49538 |
| 76 | 35.49646 | 5.31233 | -4.49538 |
| 77 | 15.57758 | 6.97406 | -1.57857 |
| 78 | 22.21721 | 6.97406 | -1.57857 |
| 79 | 28.85683 | 6.97406 | -1.57857 |
| 80 | 35.49646 | 6.97406 | -1.57857 |
| 81 | 39.48652 | 1.21352 | -5.94400 |
| 82 | 40.63578 | .34702 | -4.96000 |
| 83 | 41.40190 | .52021 | -2.97600 |
| 84 | 41.78495 | .17340 | -.99200 |
| 85 | 39.48652 | 3.45659 | -5.83685 |
| 86 | 40.63578 | 2.46906 | -4.20489 |
| 87 | 41.40190 | 1.48143 | -2.52253 |
| 88 | 41.78495 | .49381 | -.84098 |
| 89 | 39.48652 | 5.17323 | -3.93345 |
| 90 | 40.63578 | 3.69520 | -2.80962 |
| 91 | 41.40190 | 2.21712 | -1.68577 |
| 92 | 41.78495 | .73904 | -.56192 |
| 93 | 39.48652 | 6.10231 | -1.38125 |
| 94 | 40.63578 | 4.35879 | -.98661 |
| 95 | 41.40190 | 2.61527 | -.59195 |
| 96 | 41.78495 | .87176 | -.19732 |
| 97 | .38306 | -.17340 | .99200 |
| 98 | 1.91528 | -.52021 | 2.97600 |
| 99 | 4.97972 | -.86702 | 4.96000 |
| 100 | 9.57638 | -1.21382 | 5.94400 |
| 101 | .38306 | -.49381 | .84098 |
| 102 | 1.91528 | -1.48143 | 2.52253 |
| 103 | 4.97972 | -2.46906 | 4.20489 |
| 104 | 9.57638 | -3.45668 | 5.83684 |
| 105 | .38306 | -.73904 | .56192 |
| 106 | 1.91528 | -2.21712 | 1.68577 |
| 107 | 4.97972 | -3.69520 | 2.80962 |
| 108 | 9.57638 | -5.17328 | 3.93345 |
| 109 | .38306 | -.87176 | .19732 |
| 110 | 1.91528 | -2.61527 | .59195 |
| 111 | 4.97972 | -4.35879 | .98661 |
| 112 | 9.57638 | -6.10231 | 1.38125 |
| 113 | 15.57758 | -1.38723 | 7.93600 |
| 114 | 22.21721 | -1.38723 | 7.93600 |
| 115 | 28.85683 | -1.38723 | 7.93600 |
| 116 | 35.49646 | -1.38723 | 7.93600 |
| 117 | 15.57758 | -3.95049 | 6.72782 |
| 118 | 22.21721 | -3.95049 | 6.72782 |
| 119 | 28.85683 | -3.95049 | 6.72782 |
| 120 | 35.49646 | -3.95049 | 6.72782 |
| 121 | 15.57758 | -5.31233 | 4.49538 |
| 122 | 22.21721 | -5.31233 | 4.49538 |
| 123 | 28.85683 | -5.31233 | 4.49538 |
| 124 | 35.49646 | -5.31233 | 4.49538 |
| 125 | 15.57758 | -6.97406 | 1.57857 |
| 126 | 22.21721 | -6.97406 | 1.57857 |
| 127 | 28.85683 | -6.97406 | 1.57857 |
| 128 | 35.49646 | -6.97406 | 1.57857 |
| 129 | 39.48652 | -1.21352 | 5.94400 |
| 130 | 40.63578 | -.34702 | 4.96000 |
| 131 | 41.40190 | -.52021 | 2.97600 |
| 132 | 41.78495 | -.17340 | .99200 |
| 133 | 39.48652 | -3.45659 | 5.83685 |
| 134 | 40.63578 | -2.46906 | 4.20489 |
| 135 | 41.40190 | -1.48143 | 2.52253 |

| | | | |
|---|---|---|---|
| 136 | 41.78495 | -.49331 | .34098 |
| 137 | 39.48662 | -5.17323 | 3.93346 |
| 138 | 40.63578 | -3.59520 | 2.80962 |
| 139 | 41.40190 | -2.21712 | 1.68577 |
| 140 | 41.78495 | -.73904 | .56192 |
| 141 | 39.48662 | -6.10231 | 1.36125 |
| 142 | 40.63578 | -4.35879 | .95561 |
| 143 | 41.40190 | -2.51527 | .59196 |
| 144 | 41.78495 | -.87175 | .19732 |
| 145 | .38306 | -.17340 | -.99200 |
| 146 | 1.91528 | -.52021 | -2.97600 |
| 147 | 4.97972 | -.85702 | -4.96000 |
| 148 | 9.57638 | -1.21382 | -6.94400 |
| 149 | .38306 | -.49331 | -.84099 |
| 150 | 1.91528 | -1.48143 | -2.52293 |
| 151 | 4.97972 | -2.46905 | -4.20489 |
| 152 | 9.57638 | -3.45668 | -5.88684 |
| 153 | .38306 | -.73904 | -.56192 |
| 154 | 1.91528 | -2.21712 | -1.68577 |
| 155 | 4.97972 | -3.69520 | -2.80962 |
| 156 | 9.57638 | -5.17323 | -3.93346 |
| 157 | .38306 | -.87175 | -.19732 |
| 158 | 1.91528 | -2.61527 | -.59196 |
| 159 | 4.97972 | -4.35879 | -.98661 |
| 160 | 9.57638 | -6.10231 | -1.38125 |
| 161 | 15.57758 | -1.38723 | -7.93600 |
| 162 | 22.21721 | -1.38723 | -7.93600 |
| 163 | 28.85683 | -1.38723 | -7.93600 |
| 164 | 35.49646 | -1.38723 | -7.93600 |
| 165 | 15.57758 | -3.95049 | -6.72782 |
| 166 | 22.21721 | -3.95049 | -6.72782 |
| 167 | 28.85683 | -3.95049 | -6.72782 |
| 168 | 35.49646 | -3.95049 | -6.72782 |
| 169 | 15.57758 | -5.91233 | -4.49538 |
| 170 | 22.21721 | -5.91233 | -4.49538 |
| 171 | 28.85683 | -5.91233 | -4.49539 |
| 172 | 35.49646 | -5.91233 | -4.49538 |
| 173 | 15.57758 | -6.97405 | -1.57857 |
| 174 | 22.21721 | -6.97405 | -1.57857 |
| 175 | 28.85683 | -6.97405 | -1.57857 |
| 176 | 35.49646 | -6.97405 | -1.57857 |
| 177 | 39.48662 | -1.21382 | -6.94400 |
| 178 | 40.63578 | -.85702 | -4.96000 |
| 179 | 41.40190 | -.52021 | -2.97600 |
| 180 | 41.78495 | -.17340 | -.99200 |
| 181 | 39.48662 | -3.45668 | -5.88684 |
| 182 | 40.63578 | -2.46905 | -4.20489 |
| 183 | 41.40190 | -1.48143 | -2.52293 |
| 184 | 41.78495 | -.49331 | -.84098 |
| 185 | 39.48662 | -5.17323 | -3.93346 |
| 186 | 40.63578 | -3.69520 | -2.80962 |
| 187 | 41.40190 | -2.21712 | -1.68577 |
| 188 | 41.78495 | -.73904 | -.56192 |
| 189 | 39.48662 | -6.10231 | -1.38123 |
| 190 | 40.63578 | -4.35879 | -.98661 |
| 191 | 41.40190 | -2.61527 | -.59196 |
| 192 | 41.78495 | -.87175 | -.19732 |

## Nodal Numbering for Surfaces

FOR SURFACE 1

| | | | | |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 |
| 2 | 6 | 10 | 14 | 18 |
| 3 | 7 | 11 | 15 | 19 |
| 4 | 8 | 12 | 16 | 20 |
| 5 | 9 | 13 | 17 | 21 |

FOR SURFACE 2

| | | | | |
|---|---|---|---|---|
| 5 | 9 | 13 | 17 | 21 |
| 22 | 26 | 30 | 34 | 38 |
| 23 | 27 | 31 | 35 | 39 |
| 24 | 28 | 32 | 36 | 40 |
| 25 | 29 | 33 | 37 | 41 |

FOR SURFACE 3

| | | | | |
|---|---|---|---|---|
| 25 | 29 | 33 | 37 | 41 |
| 42 | 46 | 49 | 52 | 55 |
| 43 | 47 | 50 | 53 | 56 |
| 44 | 48 | 51 | 54 | 57 |
| 45 | 45 | 45 | 45 | 45 |

FOR SURFACE 5

| | | | | |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 |
| 58 | 62 | 66 | 70 | 18 |
| 59 | 63 | 67 | 71 | 19 |
| 60 | 64 | 68 | 72 | 20 |
| 61 | 65 | 69 | 73 | 21 |

FOR SURFACE 6

| | | | | |
|---|---|---|---|---|
| 61 | 65 | 69 | 73 | 21 |
| 74 | 78 | 82 | 86 | 38 |
| 75 | 79 | 83 | 87 | 39 |
| 76 | 80 | 84 | 88 | 40 |
| 77 | 81 | 85 | 89 | 41 |

FOR SURFACE 7

| | | | | |
|---|---|---|---|---|
| 77 | 81 | 85 | 89 | 41 |
| 90 | 93 | 96 | 99 | 55 |
| 91 | 94 | 97 | 100 | 56 |
| 92 | 95 | 98 | 101 | 57 |
| 45 | 45 | 45 | 45 | 45 |

FOR SURFACE 9

| | | | | |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 |
| 2 | 102 | 106 | 110 | 114 |
| 3 | 103 | 107 | 111 | 115 |
| 4 | 104 | 108 | 112 | 116 |
| 5 | 105 | 109 | 113 | 117 |

FOR SURFACE 10

| | | | | |
|---|---|---|---|---|
| 5 | 105 | 109 | 113 | 117 |
| 22 | 118 | 122 | 126 | 130 |
| 23 | 119 | 123 | 127 | 131 |
| 24 | 120 | 124 | 128 | 132 |
| 25 | 121 | 125 | 129 | 133 |

FOR SURFACE 11

| | | | | |
|---|---|---|---|---|
| 25 | 121 | 125 | 129 | 133 |
| 42 | 134 | 137 | 140 | 143 |
| 43 | 135 | 138 | 141 | 144 |
| 44 | 136 | 139 | 142 | 145 |
| 45 | 45 | 45 | 45 | 45 |

FOR SURFACE 13

| | | | | |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 |
| 58 | 146 | 150 | 154 | 114 |
| 59 | 147 | 151 | 155 | 115 |
| 60 | 148 | 152 | 156 | 116 |
| 61 | 149 | 153 | 157 | 117 |

FOR SURFACE 14

| | | | | |
|---|---|---|---|---|
| 61 | 149 | 153 | 157 | 117 |
| 74 | 158 | 162 | 166 | 130 |
| 75 | 159 | 163 | 167 | 131 |
| 76 | 160 | 164 | 168 | 132 |
| 77 | 161 | 165 | 169 | 133 |

FOR SURFACE 15

| | | | | |
|---|---|---|---|---|
| 77 | 161 | 165 | 169 | 133 |
| 90 | 170 | 173 | 176 | 143 |
| 91 | 171 | 174 | 177 | 144 |
| 92 | 172 | 175 | 178 | 145 |
| 45 | 45 | 45 | 45 | 45 |

## Nodal Numbering for Elements

| ELEM | ++ | +- | -+ | -- |
|---|---|---|---|---|
| 1 | [illegible] | 2 | 1 | 1 |
| 2 | 7 | 3 | 5 | 2 |
| 3 | 9 | 4 | 7 | 3 |
| 4 | 9 | 5 | [illegible] | 4 |
| 5 | 10 | 6 | 1 | 1 |
| 6 | 11 | 7 | 10 | 6 |
| 7 | 12 | 8 | 11 | 7 |
| 8 | 13 | 9 | 12 | 8 |
| 9 | 14 | 10 | 1 | 1 |
| 10 | 15 | 11 | 14 | 10 |
| 11 | 16 | 12 | 15 | 11 |
| 12 | 17 | 13 | 16 | 12 |
| 13 | 18 | 14 | 1 | 1 |
| 14 | 19 | 15 | 18 | 14 |
| 15 | 20 | 16 | 19 | 15 |
| 16 | 21 | 17 | 20 | 16 |
| 17 | 26 | 22 | 3 | 5 |
| 18 | 27 | 23 | 25 | 22 |
| 19 | 28 | 24 | 27 | 23 |
| 20 | 29 | 25 | 28 | 24 |
| 21 | 30 | 26 | 13 | 9 |
| 22 | 31 | 27 | 30 | 26 |
| 23 | 32 | 28 | 31 | 27 |
| 24 | 33 | 29 | 32 | 28 |
| 25 | 34 | 30 | 17 | 13 |
| 26 | 35 | 31 | 34 | 30 |
| 27 | 36 | 32 | 35 | 31 |
| 28 | 37 | 33 | 36 | 32 |
| 29 | 38 | 34 | 21 | 17 |
| 30 | 39 | 36 | 38 | 34 |
| 31 | 40 | 35 | 39 | 35 |
| 32 | 41 | 37 | 40 | 36 |
| 33 | 46 | 42 | 25 | 25 |
| 34 | 47 | 43 | 48 | 42 |
| 35 | 48 | 44 | 47 | 43 |
| 36 | 45 | 45 | 45 | 44 |
| 37 | 49 | 46 | 33 | 29 |
| 38 | 50 | 47 | 49 | 46 |
| 39 | 51 | 48 | 50 | 47 |
| 40 | 45 | 45 | 51 | 48 |
| 41 | 52 | 49 | 37 | 33 |
| 42 | 53 | 50 | 52 | 49 |
| 43 | 54 | 51 | 53 | 50 |
| 44 | 45 | 45 | 54 | 51 |
| 45 | 55 | 52 | 41 | 37 |
| 46 | 56 | 53 | 55 | 52 |
| 47 | 57 | 54 | 56 | 53 |
| 48 | 45 | 45 | 57 | 54 |
| 49 | 58 | 62 | 1 | 1 |
| 50 | 59 | 63 | 59 | 62 |
| 51 | 60 | 64 | 59 | 63 |
| 52 | 61 | 65 | 60 | 64 |
| 53 | 62 | 66 | 1 | 1 |
| 54 | 63 | 67 | 62 | 66 |
| 55 | 64 | 68 | 63 | 67 |
| 56 | 65 | 69 | 64 | 68 |
| 57 | 66 | 70 | 1 | 1 |
| 58 | 67 | 71 | 66 | 70 |
| 59 | 68 | 72 | 67 | 71 |
| 60 | 69 | 73 | 68 | 72 |
| 61 | 70 | 18 | 1 | 1 |
| 62 | 71 | 19 | 70 | 18 |
| 63 | 72 | 20 | 71 | 19 |
| 64 | 73 | 21 | 72 | 20 |

| | | | | |
|---|---|---|---|---|
| 65 | 74 | 78 | 61 | [illegible] |
| 66 | 75 | 79 | 74 | [illegible] |
| 67 | 76 | 80 | 75 | [illegible] |
| 68 | 77 | 81 | 75 | 80 |
| 69 | 78 | 82 | [illegible] | [illegible] |
| 70 | 79 | 83 | 78 | [illegible] |
| 71 | [illegible] | [illegible] | [illegible] | [illegible] |
| 72 | 81 | [illegible] | 80 | [illegible] |
| 73 | 82 | [illegible] | [illegible] | [illegible] |
| 74 | 83 | 87 | 82 | 86 |
| 75 | [illegible] | [illegible] | [illegible] | [illegible] |
| 76 | [illegible] | 89 | [illegible] | [illegible] |
| 77 | [illegible] | [illegible] | [illegible] | 21 |
| 78 | [illegible] | [illegible] | [illegible] | [illegible] |
| 79 | [illegible] | [illegible] | [illegible] | [illegible] |
| 80 | 89 | [illegible] | 88 | [illegible] |
| 81 | 90 | [illegible] | [illegible] | [illegible] |
| 82 | [illegible] | [illegible] | [illegible] | [illegible] |
| 83 | 92 | [illegible] | 91 | [illegible] |
| 84 | [illegible] | [illegible] | 92 | [illegible] |
| 85 | 93 | 96 | 31 | [illegible] |
| 86 | 94 | 97 | 93 | [illegible] |
| 87 | [illegible] | [illegible] | [illegible] | [illegible] |
| 88 | [illegible] | [illegible] | [illegible] | [illegible] |
| 89 | [illegible] | [illegible] | [illegible] | [illegible] |
| 90 | 97 | 100 | [illegible] | [illegible] |
| 91 | 99 | 101 | [illegible] | 100 |
| 92 | [illegible] | [illegible] | [illegible] | 101 |
| 93 | 99 | [illegible] | [illegible] | [illegible] |
| 94 | 100 | [illegible] | [illegible] | [illegible] |
| 95 | 101 | [illegible] | [illegible] | [illegible] |
| 96 | [illegible] | [illegible] | 101 | [illegible] |
| 97 | 2 | 102 | 1 | 1 |
| 98 | 3 | [illegible] | 2 | [illegible] |
| 99 | 4 | 104 | 3 | 103 |
| 100 | 5 | [illegible] | [illegible] | [illegible] |
| 101 | 102 | [illegible] | 1 | 1 |
| 102 | 103 | 107 | 102 | 106 |
| 103 | 104 | [illegible] | [illegible] | [illegible] |
| 104 | 105 | 109 | [illegible] | [illegible] |
| 105 | 106 | 110 | 1 | 1 |
| 106 | 107 | 111 | [illegible] | 110 |
| 107 | [illegible] | 112 | 107 | 111 |
| 108 | 109 | 113 | 108 | 112 |
| 109 | [illegible] | 114 | 1 | 1 |
| 110 | 111 | 115 | 110 | 114 |
| 111 | 112 | 116 | 111 | 115 |
| 112 | 113 | 117 | 112 | 116 |
| 113 | 22 | 118 | 5 | 105 |
| 114 | 23 | 119 | 22 | 118 |
| 115 | 24 | 120 | 23 | 119 |
| 116 | 25 | 121 | 24 | 120 |
| 117 | 118 | 122 | 105 | 109 |
| 118 | 119 | 123 | 118 | 122 |
| 119 | 120 | 124 | 119 | 123 |
| 120 | 121 | 125 | 120 | 124 |
| 121 | 122 | [illegible] | 119 | 113 |
| 122 | 123 | 127 | 122 | 125 |
| 123 | 124 | 128 | 123 | 127 |
| 124 | 125 | 129 | 124 | 128 |
| 125 | 125 | 130 | 113 | 117 |
| 126 | 127 | 131 | 126 | 130 |
| 127 | [illegible] | 132 | 127 | 131 |
| 128 | 129 | 133 | [illegible] | 132 |

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FROM COPY FURNISHED TO DDC

| | | | | |
|---|---|---|---|---|
| 129 | 42 | 134 | 25 | 121 |
| 130 | 43 | 135 | 42 | 134 |
| 131 | 44 | 136 | 43 | 135 |
| 132 | 45 | 45 | 44 | 136 |
| 133 | 134 | 137 | 121 | 125 |
| 134 | 135 | 138 | 134 | 137 |
| 135 | 136 | 139 | 135 | 138 |
| 136 | 45 | 45 | 136 | 139 |
| 137 | 137 | 140 | 125 | 129 |
| 138 | 138 | 141 | 137 | 140 |
| 139 | 139 | 142 | 138 | 141 |
| 140 | 45 | 45 | 139 | 142 |
| 141 | 140 | 143 | 121 | 133 |
| 142 | 141 | 144 | 140 | 143 |
| 143 | 142 | 145 | 141 | 144 |
| 144 | 45 | 45 | 142 | 145 |
| 145 | 146 | 58 | 1 | 1 |
| 146 | 147 | 59 | 146 | 58 |
| 147 | 148 | 60 | 147 | 59 |
| 148 | 149 | 61 | 148 | 60 |
| 149 | 150 | 146 | 1 | 1 |
| 150 | 151 | 147 | 150 | 146 |
| 151 | 152 | 148 | 151 | 147 |
| 152 | 153 | 149 | 152 | 148 |
| 153 | 154 | 150 | 1 | 1 |
| 154 | 155 | 151 | 154 | 150 |
| 155 | 156 | 152 | 155 | 151 |
| 156 | 157 | 153 | 156 | 152 |
| 157 | 114 | 154 | 1 | 1 |
| 158 | 115 | 155 | 114 | 154 |
| 159 | 116 | 156 | 115 | 155 |
| 160 | 117 | 157 | 116 | 156 |
| 161 | 153 | 74 | 143 | 61 |
| 162 | 159 | 75 | 153 | 74 |
| 163 | 160 | 76 | 159 | 75 |
| 164 | 161 | 77 | 160 | 76 |
| 165 | 162 | 158 | 153 | 149 |
| 166 | 163 | 159 | 162 | 158 |
| 167 | 164 | 160 | 163 | 159 |
| 168 | 165 | 161 | 164 | 160 |
| 169 | 165 | 162 | 157 | 153 |
| 170 | 167 | 163 | 166 | 162 |
| 171 | 166 | 164 | 167 | 163 |
| 172 | 169 | 165 | 168 | 164 |
| 173 | 130 | 166 | 117 | 157 |
| 174 | 131 | 167 | 130 | 166 |
| 175 | 132 | 168 | 131 | 167 |
| 176 | 133 | 169 | 132 | 168 |
| 177 | 170 | 90 | 151 | 77 |
| 178 | 171 | 91 | 170 | 90 |
| 179 | 172 | 92 | 171 | 91 |
| 180 | 45 | 45 | 172 | 92 |
| 181 | 173 | 170 | 165 | 161 |
| 182 | 174 | 171 | 173 | 170 |
| 183 | 175 | 172 | 174 | 171 |
| 184 | 45 | 45 | 173 | 172 |
| 185 | 176 | 173 | 169 | 165 |
| 186 | 177 | 174 | 176 | 173 |
| 187 | 173 | 175 | 177 | 174 |
| 188 | 45 | 45 | 173 | 175 |
| 189 | 143 | 176 | 133 | 169 |
| 190 | 144 | 177 | 143 | 176 |
| 191 | 145 | 178 | 144 | 177 |
| 192 | 45 | 45 | 145 | 178 |

# The Distribution of the Source

FOR SUBSURFACE 1

| | | | |
|---|---|---|---|
| -.11944E+04 | -.11943E+04 | -.11941E+04 | -.11940E+04 |
| -.11322E+04 | -.11317E+04 | -.11309E+04 | -.11304E+04 |
| -.10005E+04 | -.99957E+03 | -.99827E+03 | -.99738E+03 |
| -.75270E+03 | -.75175E+03 | -.75051E+03 | -.74969E+03 |

FOR SUBSURFACE 2

| | | | |
|---|---|---|---|
| -.29311E+03 | -.29549E+03 | -.29875E+03 | -.30098E+03 |
| -.41211E+02 | -.41535E+02 | -.41983E+02 | -.42293E+02 |
| .18245E+03 | .18456E+03 | .18757E+03 | .18973E+03 |
| .50453E+03 | .51393E+03 | .51987E+03 | .52610E+03 |

FOR SUBSURFACE 3

| | | | |
|---|---|---|---|
| .10697E+04 | .10742E+04 | .10805E+04 | .10848E+04 |
| .13099E+04 | .13115E+04 | .13137E+04 | .13153E+04 |
| .14415E+04 | .14419E+04 | .14425E+04 | .14431E+04 |
| .15021E+04 | .15022E+04 | .15022E+04 | .15023E+04 |

FOR SUBSURFACE 5

| | | | |
|---|---|---|---|
| -.11944E+04 | -.11943E+04 | -.11941E+04 | -.11940E+04 |
| -.11322E+04 | -.11317E+04 | -.11309E+04 | -.11304E+04 |
| -.10005E+04 | -.99957E+03 | -.99827E+03 | -.99738E+03 |
| -.75270E+03 | -.75175E+03 | -.75051E+03 | -.74969E+03 |

FOR SUBSURFACE 6

| | | | |
|---|---|---|---|
| -.29311E+03 | -.29549E+03 | -.29875E+03 | -.30398E+03 |
| -.41211E+02 | -.41535E+02 | -.41983E+02 | -.42293E+02 |
| .18245E+03 | .18456E+03 | .18757E+03 | .18973E+03 |
| .50453E+03 | .51093E+03 | .51987E+03 | .52610E+03 |

FOR SUBSURFACE 7

| | | | |
|---|---|---|---|
| .10697E+04 | .10742E+04 | .10805E+04 | .10848E+04 |
| .13099E+04 | .13115E+04 | .13137E+04 | .13153E+04 |
| .14415E+04 | .14419E+04 | .14426E+04 | .14431E+04 |
| .15021E+04 | .15022E+04 | .15022E+04 | .15023E+04 |

FOR SUBSURFACE 8

| | | | |
|---|---|---|---|
| -.11944E+04 | -.11943E+04 | -.11941E+04 | -.11940E+04 |
| -.11322E+04 | -.11317E+04 | -.11309E+04 | -.11304E+04 |
| -.10005E+04 | -.99957E+03 | -.99627E+03 | -.99738E+03 |
| -.75270E+03 | -.75175E+03 | -.75051E+03 | -.74369E+03 |

FOR SUBSURFACE 10

| | | | |
|---|---|---|---|
| -.29311E+03 | -.29549E+03 | -.29875E+03 | -.30098E+03 |
| -.41211E+02 | -.41535E+02 | -.41983E+02 | -.42293E+02 |
| .18245E+03 | .18456E+03 | .18757E+03 | .18973E+03 |
| .50453E+03 | .51093E+03 | .51987E+03 | .52610E+03 |

FOR SUBSURFACE 11

| | | | |
|---|---|---|---|
| .10697E+04 | .10742E+04 | .10805E+04 | .10848E+04 |
| .13099E+04 | .13115E+04 | .13137E+04 | .13153E+04 |
| .14415E+04 | .14419E+04 | .14426E+04 | .14431E+04 |
| .15021E+04 | .15022E+04 | .15022E+04 | .15023E+04 |

FOR SUBSURFACE 13

| | | | |
|---|---|---|---|
| -.11944E+04 | -.11343E+04 | -.11941E+04 | -.11940E+04 |
| -.11322E+04 | -.11317E+04 | -.11309E+04 | -.11304E+04 |
| -.10005E+04 | -.99937E+03 | -.99827E+03 | -.99738E+03 |
| -.75270E+03 | -.75175E+03 | -.75051E+03 | -.74969E+03 |

FOR SUBSURFACE 14

| | | | |
|---|---|---|---|
| -.29311E+03 | -.29549E+03 | -.29875E+03 | -.30098E+03 |
| -.41211E+02 | -.41335E+02 | -.41983E+02 | -.42293E+02 |
| .18245E+03 | .18456E+03 | .18757E+03 | .18973E+03 |
| .50453E+03 | .51133E+03 | .51987E+03 | .52510E+03 |

FOR SUBSURFACE 15

| | | | |
|---|---|---|---|
| .10697E+04 | .10742E+04 | .10805E+04 | .10848E+04 |
| .13099E+04 | .13115E+04 | .13137E+04 | .13153E+04 |
| .14415E+04 | .14419E+04 | .14426E+04 | .14431E+04 |
| .15021E+04 | .15022E+04 | .15022E+04 | .15023E+04 |

## The Distribution of the Velocity Potential

FOR SUBSURFACE 1

| | | | |
|---|---|---|---|
| -.67872E+03 | -.67879E+03 | -.67892E+03 | -.67915E+03 |
| -.64670E+03 | -.64671E+03 | -.64696E+03 | -.64760E+03 |
| -.58307E+03 | -.58329E+03 | -.58396E+03 | -.58536E+03 |
| -.45087E+03 | -.45151E+03 | -.45303E+03 | -.45560E+03 |

FOR SUBSURFACE 2

| | | | |
|---|---|---|---|
| -.12407E+03 | -.12732E+03 | -.13424E+03 | -.14102E+03 |
| -.11810E+02 | -.15937E+02 | -.22830E+02 | -.31136E+02 |
| .78425E+02 | .72959E+02 | .63175E+02 | .51499E+02 |
| .21893E+03 | .21015E+03 | .19549E+03 | .17049E+03 |

FOR SUBSURFACE 3

| | | | |
|---|---|---|---|
| .76572E+03 | .75131E+03 | .72782E+03 | .70411E+03 |
| .90453E+03 | .89511E+03 | .87721E+03 | .85861E+03 |
| .96299E+03 | .95337E+03 | .94101E+03 | .92914E+03 |
| .96505E+03 | .96313E+03 | .95990E+03 | .95621E+03 |

FOR SUBSURFACE 5

| | | | |
|---|---|---|---|
| -.68045E+03 | -.68025E+03 | -.67989E+03 | -.67949E+03 |
| -.65243E+03 | -.65137E+03 | -.65018E+03 | -.64874E+03 |
| -.59367E+03 | -.59226E+03 | -.58995E+03 | -.58746E+03 |
| -.46828E+03 | -.45626E+03 | -.46289E+03 | -.45906E+03 |

FOR SUBSURFACE 6

| | | | |
|---|---|---|---|
| -.15193E+03 | -.15151E+03 | -.14998E+03 | -.14654E+03 |
| -.52254E+02 | -.50033E+02 | -.45609E+02 | -.33118E+02 |
| .18535E+02 | .22424E+02 | .29785E+02 | .33850E+02 |
| .12757E+03 | .13428E+03 | .14625E+03 | .15155E+03 |

FOR SUBSURFACE 7

| | | | |
|---|---|---|---|
| .65948E+03 | .66364E+03 | .67205E+03 | .68527E+03 |
| .82571E+03 | .82937E+03 | .83416E+03 | .84398E+03 |
| .90704E+03 | .90935E+03 | .91303E+03 | .91967E+03 |
| .94695E+03 | .94796E+03 | .94991E+03 | .95274E+03 |

FOR SUBSURFACE 9

| | | | |
|---|---|---|---|
| -.67872E+03 | -.67379E+03 | -.67692E+03 | -.67915E+03 |
| -.64670E+03 | -.64671E+03 | -.64694E+03 | -.64760E+03 |
| -.56307E+03 | -.58328E+03 | -.58396E+03 | -.58536E+03 |
| -.45087E+03 | -.45151E+03 | -.45303E+03 | -.45560E+03 |

FOR SUBSURFACE 10

| | | | |
|---|---|---|---|
| -.12407E+03 | -.12732E+03 | -.13426E+03 | -.14102E+03 |
| -.11810E+02 | -.15837E+02 | -.22830E+02 | -.31136E+02 |
| .78425E+02 | .72859E+02 | .63175E+02 | .51499E+02 |
| .21893E+03 | .21015E+03 | .19549E+03 | .17849E+03 |

FOR SUBSURFACE 11

| | | | |
|---|---|---|---|
| .76572E+03 | .75131E+03 | .72782E+03 | .70411E+03 |
| .90453E+03 | .89511E+03 | .87721E+03 | .85361E+03 |
| .96298E+03 | .95357E+03 | .94101E+03 | .92914E+03 |
| .96503E+03 | .95313E+03 | .95950E+03 | .95621E+03 |

FOR SUBSURFACE 13

| | | | |
|---|---|---|---|
| -.68045E+03 | -.68025E+03 | -.67985E+03 | -.67949E+03 |
| -.65243E+03 | -.65157E+03 | -.65016E+03 | -.64874E+03 |
| -.59387E+03 | -.59226E+03 | -.58995E+03 | -.58746E+03 |
| -.46828E+03 | -.46626E+03 | -.46289E+03 | -.45906E+03 |

FOR SUBSURFACE 14

| | | | |
|---|---|---|---|
| -.15193E+03 | -.15151E+03 | -.14998E+03 | -.14654E+03 |
| -.52254E+02 | [illegible] | -.45609E+02 | -.33116E+02 |
| .18535E+02 | .22424E+02 | .29785E+02 | .39350E+02 |
| .12757E+03 | .13429E+03 | .14625E+03 | .16155E+03 |

FOR SUBSURFACE 15

| | | | |
|---|---|---|---|
| .65948E+03 | .65354E+03 | .67205E+03 | .68527E+03 |
| .82571E+03 | .82837E+03 | .83416E+03 | .84398E+03 |
| .90764E+03 | [illegible] | .91303E+03 | .91967E+03 |
| .94696E+03 | .94795E+03 | .94991E+03 | .95274E+03 |

## Pressure Distribution

FOR SUBSURFACE 1

| | | | |
|---|---|---|---|
| .61577E+00 | .1[illegible]273E+01 | .11126E+01 | .11920E+01 |
| .66014E+00 | -.10644E+00 | -.10991E+00 | -.11134E+00 |
| -.17570E+00 | -.17734E+00 | -.17999E+00 | -.18[illegible]45E+00 |
| -.32859E+00 | -.32903E+00 | -.32882E+00 | -.32753E+00 |

FOR SUBSURFACE 2

| | | | |
|---|---|---|---|
| -.28964E+00 | -.28751E+00 | -.28430E+00 | -.28075E+00 |
| -.13356E+00 | -.13263E+00 | -.13023E+00 | -.12704E+00 |
| -.15172E+00 | -.14859E+00 | -.14413E+00 | -.13851E+00 |
| -.45281E+00 | -.44751E+00 | -.43959E+00 | -.43215E+00 |

FOR SUBSURFACE 3

| | | | |
|---|---|---|---|
| -.69056E+00 | -.72871E+00 | -.77607E+00 | -.80926E+00 |
| -.16858E+00 | -.15559E+00 | -.21181E+00 | -.23123E+00 |
| -.36355E-01 | -.45608E-01 | -.58911E-01 | -.7[illegible]382E-01 |
| .28684E-02 | .19030E-03 | -.34147E-02 | -.67867E-02 |

FOR SUBSURFACE 5

| | | | |
|---|---|---|---|
| .96689E+00 | .10318E+01 | .11214E+01 | .11330E+01 |
| -.94236E-01 | -.98972E-01 | -.10516E+00 | -.10972E+00 |
| -.16570E+00 | -.16370E+00 | -.17483E+03 | -.17870E+00 |
| -.31676E+00 | -.31937E+00 | -.32266E+00 | -.32543E+00 |

FOR SUBSURFACE 6

| | | | |
|---|---|---|---|
| -.27501E+00 | -.27525E+00 | -.27607E+00 | -.27787E+00 |
| -.11324E+00 | -.11536E+00 | -.11895E+00 | -.12311E+00 |
| -.11960E+00 | -.12233E+00 | -.12702E+00 | -.13266E+00 |
| -.42368E+00 | -.42335E+00 | -.42466E+00 | -.42726E+00 |

FOR SUBSURFACE 7

| | | | |
|---|---|---|---|
| -.70167E+00 | -.73426E+00 | -.77709E+00 | -.30523E+00 |
| -.20893E+00 | -.21340E+00 | -.23233E+00 | -.23817E+00 |
| -.69518E-01 | -.72507E-01 | -.76396E-01 | -.76379E-01 |
| -.11431E-01 | -.11401E-01 | -.10677E-01 | -.93713E-02 |

FOR SUBSURFACE 9

| | | | |
|---|---|---|---|
| .61577E+00 | .10275E+01 | .11136E+01 | .11620E+01 |
| .66014E+00 | -.10544E+00 | -.10991E+00 | -.11134E+00 |
| -.17570E+00 | -.17794E+00 | -.17959E+00 | -.19045E+00 |
| -.32859E+00 | -.32903E+00 | -.32882E+00 | -.32753E+00 |

FOR SUBSURFACE 10

| | | | |
|---|---|---|---|
| -.28964E+00 | -.29751E+00 | -.28430E+00 | -.29075E+00 |
| -.13356E+00 | -.13243E+00 | -.13023E+00 | -.12704E+00 |
| -.15172E+00 | -.14339E+00 | -.14413E+00 | -.13651E+00 |
| -.45281E+00 | -.44751E+00 | -.43959E+00 | -.43215E+00 |

FOR SUBSURFACE 11

| | | | |
|---|---|---|---|
| -.69056E+00 | -.72371E+00 | -.77607E+00 | -.80526E+00 |
| -.16858E+00 | -.18558E+00 | -.21161E+00 | -.23123E+00 |
| -.36355E-01 | -.45509E-01 | -.58911E-01 | -.70362E-01 |
| .28684E-02 | .19050E-03 | -.34147E-02 | -.67367E-02 |

FOR SUBSURFACE 13

| | | | |
|---|---|---|---|
| .96689E+00 | .10318E+01 | .11214E+01 | .11630E+01 |
| -.94236E-01 | -.98472E-01 | -.10516E+00 | -.10972E+00 |
| -.16570E+00 | -.16970E+00 | -.17483E+00 | -.17670E+00 |
| -.31676E+00 | -.31937E+00 | -.32266E+00 | -.32543E+00 |

FOR SUBSURFACE 14

| | | | |
|---|---|---|---|
| -.27501E+00 | -.27525E+00 | -.27607E+00 | -.27787E+00 |
| -.11324E+00 | -.11536E+00 | -.11895E+00 | -.12311E+00 |
| -.11960E+00 | -.12233E+00 | -.12702E+00 | -.13266E+00 |
| -.42368E+00 | -.42395E+00 | -.42486E+00 | -.42726E+00 |

FOR SUBSURFACE 15

| | | | |
|---|---|---|---|
| -.70167E+00 | -.73426E+00 | -.77709E+00 | -.80923E+00 |
| -.21899E+00 | -.21946E+00 | -.23233E+00 | -.23517E+00 |
| -.69518E-01 | -.72807E-01 | -.76396E-01 | -.75379E-01 |
| -.11431E-01 | -.11401E-01 | -.10877E-01 | -.93713E-02 |

AD-A055 767 AEROSPACE SYSTEMS INC BURLINGTON MASS F/G 20/4
ROTOR WAKE EFFECTS ON HUB/PYLON FLOW. VOLUME II. PROGRAM SHAPES--ETC(U)
MAY 78 P SOOHOO, R B NOLL, L MORINO, N D HAMM DAAJ02-75-C-0041
UNCLASSIFIED ASI-TR-76-38-VOL-2 USARTL-TR-78-1B NL

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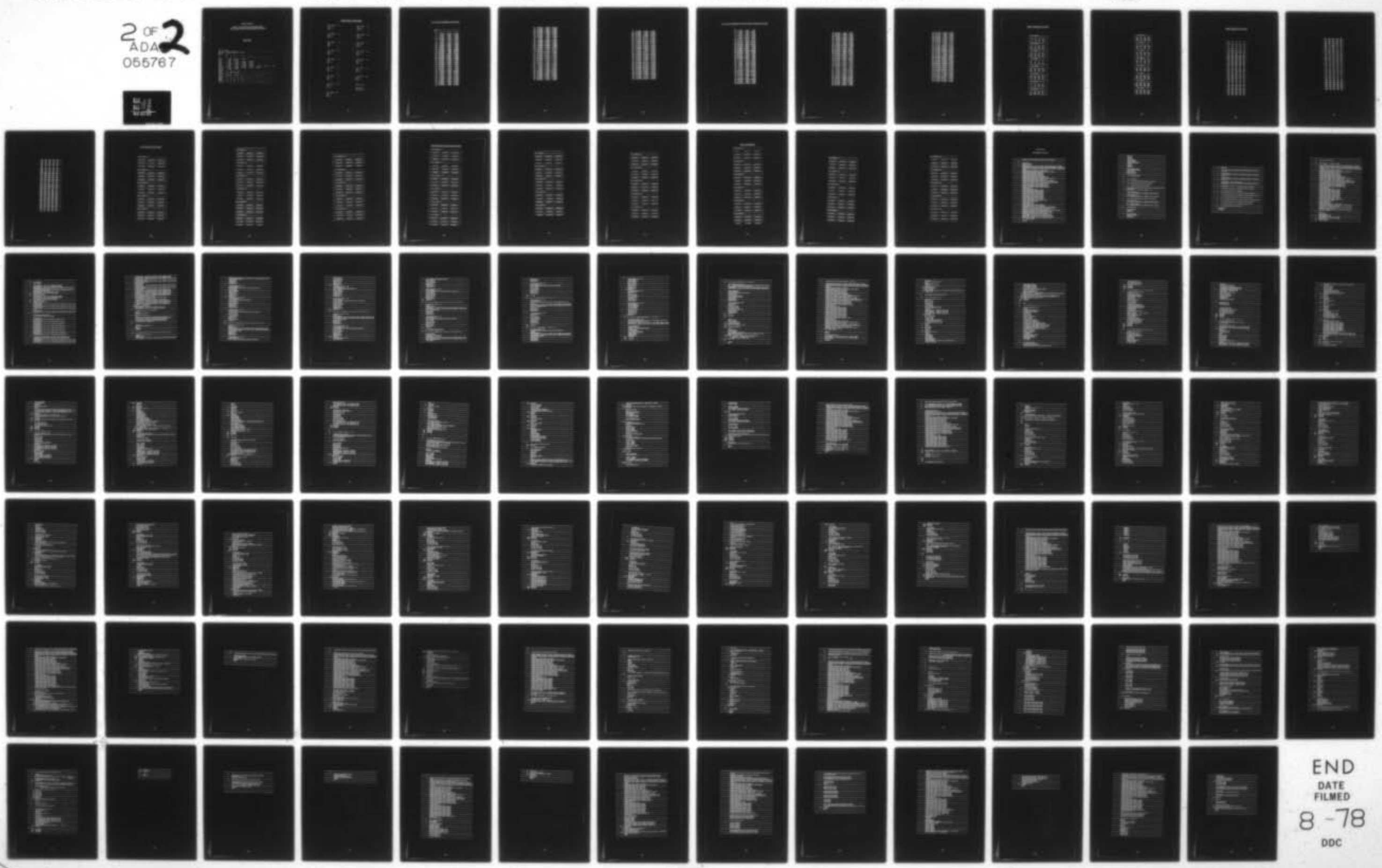

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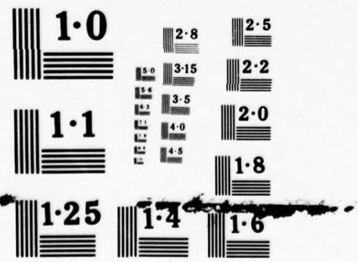

## SAMPLE CASE 4:

## MODEL 1 HELICOPTER CONFIGURATION WITH ROTOR WAKE AND SEPARATION EFFECTS

### Data Input

```
  1
PROGRAM SHAPES
HUB PYLON FLOW SEPARATION
FUSELAGE - SINGLE ROTOR (TWO BLADES)
KREAD       0
*          16     0     0
**          0     1     1     1     0     0     0     0     1
***         0     0
UMACH        .047  3600.000      -0.000
ALFA        0.000      0.000
NBODY       0.000      9.000     18.000     36.000
NBODY       0.000      0.000      0.000      0.000
NBODY       0.000      0.000      0.000      0.000
NBODY       1.450      3.250      1.450      2.900
ROTOR      20 000      8.040     11.550     15.050      0.000      0.000      .120
IHET75      0.000      0.000      0.000      0.000     90.000
RPITCH      0.000      0.000
KBLADE      2     1
NWAKE       1     0    0     1
SPIRAL     18    3.000 450.000
NPYLON      1     1
CSIAG     -60.000      1.000
KPRINT      1     1     1     1     0     1     1     1     1     1
NBODY       3     3     2     1     1
NBODY       3     3     1     1     1
NBODY       3     3     2     1     1
NROTOR      3     3     2     1     1
```

## Specifications of the Problem

```
FOR PART     1
NX= 3
NY= 3

FOR PART     2
NX= 3
NY= 3

FOR PART     3
NX= 3
NY= 3

FOR PART     5
NX= 3
NY= 3

FOR PART     6
NX= 3
NY= 3

FOR PART     7
NX= 3
NY= 3

FOR PART     9
NX= 3
NY= 3

FOR PART    10
NX= 3
NY= 3

FOR PART    11
NX= 3
NY= 3

FOR PART    13
NX= 3
NY= 3

FOR PART    14
NX= 3
NY= 3

FOR PART    15
NX= 3
NY= 3

FOR PART    24
NX= 3
NY= 3

FOR PART    25
NX= 3
NY= 3

FOR PART    27
NX= 3
NY= 3

FOR PART    28
NX= 3
NY= 3

NELEM=144

KSYMMY= 0
KSYMMZ= 0
```

## X, Y, and Z Coordinates of the Nodes

| NODE | X | Y | Z |
|---|---|---|---|
| 1 | 0.00000 | 0.00000 | 0.00000 |
| 2 | 1.00000 | -.00000 | 1.08333 |
| 3 | 4.00000 | -.00000 | 2.16667 |
| 4 | 9.00000 | .00000 | 3.25000 |
| 5 | 1.00000 | .24167 | .93819 |
| 6 | 4.00000 | .48333 | 1.87639 |
| 7 | 9.00000 | .72500 | 2.81458 |
| 8 | 1.00000 | .41858 | .54167 |
| 9 | 4.00000 | .83716 | 1.08333 |
| 10 | 9.00000 | 1.25574 | 1.62500 |
| 11 | 1.00000 | .48333 | -.00000 |
| 12 | 4.00000 | .96667 | -.00000 |
| 13 | 9.00000 | 1.45000 | -.00000 |
| 14 | 12.00000 | -.00000 | 3.13333 |
| 15 | 15.00000 | -.00000 | 3.01667 |
| 16 | 18.00000 | .00000 | 2.90000 |
| 17 | 12.00000 | .72500 | 2.71355 |
| 18 | 15.00000 | .72500 | 2.61251 |
| 19 | 18.00000 | .72500 | 2.51147 |
| 20 | 12.00000 | 1.25574 | 1.56667 |
| 21 | 15.00000 | 1.25574 | 1.50833 |
| 22 | 18.00000 | 1.25574 | 1.45000 |
| 23 | 12.00000 | 1.45000 | -.00000 |
| 24 | 15.00000 | 1.45000 | -.00000 |
| 25 | 18.00000 | 1.45000 | -.00000 |
| 26 | 28.00000 | -.00000 | 1.93333 |
| 27 | 34.00000 | -.00000 | .96667 |
| 28 | 36.00000 | 0.00000 | 0.00000 |
| 29 | 28.00000 | .48333 | 1.67432 |
| 30 | 34.00000 | .24167 | .83716 |
| 31 | 28.00000 | .83716 | .96667 |
| 32 | 34.00000 | .41858 | .48333 |
| 33 | 28.00000 | .96667 | -.00000 |
| 34 | 34.00000 | .48333 | -.00000 |
| 35 | 1.00000 | -.00000 | -1.08333 |
| 36 | 4.00000 | -.00000 | -2.16667 |
| 37 | 9.00000 | .00000 | -3.25000 |
| 38 | 1.00000 | .24167 | -.93819 |
| 39 | 4.00000 | .48333 | -1.87639 |
| 40 | 9.00000 | .72500 | -2.81458 |
| 41 | 1.00000 | .41858 | -.54167 |
| 42 | 4.00000 | .83716 | -1.08333 |
| 43 | 9.00000 | 1.25574 | -1.62500 |
| 44 | 12.00000 | -.00000 | -3.13333 |
| 45 | 15.00000 | -.00000 | -3.01667 |
| 46 | 18.00000 | .00000 | -2.90000 |
| 47 | 12.00000 | .72500 | -2.71355 |
| 48 | 15.00000 | .72500 | -2.61251 |

| | | | |
|---|---|---|---|
| 49 | 18.00000 | .72500 | -2.51147 |
| 50 | 12.00000 | 1.25574 | -1.56667 |
| 51 | 15.00000 | 1.25574 | -1.50833 |
| 52 | 18.00000 | 1.25574 | -1.45000 |
| 53 | 29.00000 | -.00000 | -1.93333 |
| 54 | 34.00000 | -.00000 | -.96667 |
| 55 | 29.00000 | .48333 | -1.67432 |
| 56 | 34.00000 | .24167 | -.83716 |
| 57 | 29.00000 | .83716 | -.96667 |
| 58 | 34.00000 | .41858 | -.48333 |
| 59 | 1.00000 | -.24167 | .93819 |
| 60 | 4.00000 | -.48333 | 1.87639 |
| 61 | 9.00000 | -.72500 | 2.81458 |
| 62 | 1.00000 | -.41858 | .54167 |
| 63 | 4.00000 | -.83716 | 1.08333 |
| 64 | 9.00000 | -1.25574 | 1.62500 |
| 65 | 1.00000 | -.48333 | -.00000 |
| 66 | 4.00000 | -.96667 | -.00000 |
| 67 | 9.00000 | -1.45000 | -.00000 |
| 68 | 12.00000 | -.72500 | 2.71355 |
| 69 | 15.00000 | -.72500 | 2.61251 |
| 70 | 18.00000 | -.72500 | 2.51147 |
| 71 | 12.00000 | -1.25574 | 1.56667 |
| 72 | 15.00000 | -1.25574 | 1.50833 |
| 73 | 18.00000 | -1.25574 | 1.45000 |
| 74 | 12.00000 | -1.45000 | -.00000 |
| 75 | 15.00000 | -1.45000 | -.00000 |
| 76 | 18.00000 | -1.45000 | -.00000 |
| 77 | 29.00000 | -.48333 | 1.67432 |
| 78 | 34.00000 | -.24167 | .83716 |
| 79 | 29.00000 | -.83716 | .96667 |
| 80 | 34.00000 | -.41858 | .48333 |
| 81 | 29.00000 | -.96667 | -.00000 |
| 82 | 34.00000 | -.48333 | -.00000 |
| 83 | 1.00000 | -.24167 | -.93819 |
| 84 | 4.00000 | -.48333 | -1.87639 |
| 85 | 9.00000 | -.72500 | -2.81458 |
| 86 | 1.00000 | -.41858 | -.54167 |
| 87 | 4.00000 | -.83716 | -1.08333 |
| 88 | 9.00000 | -1.25574 | -1.62500 |
| 89 | 12.00000 | -.72500 | -2.71355 |
| 90 | 15.00000 | -.72500 | -2.61251 |
| 91 | 18.00000 | -.72500 | -2.51147 |
| 92 | 12.00000 | -1.25574 | -1.56667 |
| 93 | 15.00000 | -1.25574 | -1.50833 |
| 94 | 18.00000 | -1.25574 | -1.45000 |
| 95 | 29.00000 | -.48333 | -1.67432 |
| 96 | 34.00000 | -.24167 | -.83716 |
| 97 | 29.00000 | -.83716 | -.96667 |

| | | | |
|---|---|---|---|
| 98 | 34.00000 | -.41858 | -.48333 |
| 99 | 11.55000 | 3.75000 | 6.67000 |
| 100 | 11.93889 | 3.75000 | 6.70462 |
| 101 | 13.10556 | 3.75000 | 6.75642 |
| 102 | 15.05000 | 3.75000 | 6.67000 |
| 103 | 11.55000 | 12.77778 | 6.67000 |
| 104 | 11.93889 | 12.77778 | 6.70462 |
| 105 | 13.10556 | 12.77778 | 6.75642 |
| 106 | 15.05000 | 12.77778 | 6.67000 |
| 107 | 11.55000 | 18.19444 | 6.67000 |
| 108 | 11.93889 | 18.19444 | 6.70462 |
| 109 | 13.10556 | 18.19444 | 6.75642 |
| 110 | 15.05000 | 18.19444 | 6.67000 |
| 111 | 11.55000 | 20.00000 | 6.67000 |
| 112 | 11.93889 | 20.00000 | 6.67000 |
| 113 | 13.10556 | 20.00000 | 6.67000 |
| 114 | 15.05000 | 20.00000 | 6.67000 |
| 115 | 11.93889 | 3.75000 | 6.63538 |
| 116 | 13.10556 | 3.75000 | 6.58358 |
| 117 | 11.93889 | 12.77778 | 6.63538 |
| 118 | 13.10556 | 12.77778 | 6.58358 |
| 119 | 11.93889 | 18.19444 | 6.63538 |
| 120 | 13.10556 | 18.19444 | 6.58358 |
| 121 | -11.55000 | -3.75000 | 6.67000 |
| 122 | -11.93889 | -3.75000 | 6.70462 |
| 123 | -13.10556 | -3.75000 | 6.75642 |
| 124 | -15.05000 | -3.75000 | 6.67000 |
| 125 | -11.55000 | -12.77778 | 6.67000 |
| 126 | -11.93889 | -12.77778 | 6.70462 |
| 127 | -13.10556 | -12.77778 | 6.75642 |
| 128 | -15.05000 | -12.77778 | 6.67000 |
| 129 | -11.55000 | -18.19444 | 6.67000 |
| 130 | -11.93889 | -18.19444 | 6.70462 |
| 131 | -13.10556 | -18.19444 | 6.75642 |
| 132 | -15.05000 | -18.19444 | 6.67000 |
| 133 | -11.55000 | -20.00000 | 6.67000 |
| 134 | -11.93889 | -20.00000 | 6.67000 |
| 135 | -13.10556 | -20.00000 | 6.67000 |
| 136 | -15.05000 | -20.00000 | 6.67000 |
| 137 | -11.93889 | -3.75000 | 6.63538 |
| 138 | -13.10556 | -3.75000 | 6.58358 |
| 139 | -11.93889 | -12.77778 | 6.63538 |
| 140 | -13.10556 | -12.77778 | 6.58358 |
| 141 | -11.93889 | -18.19444 | 6.63538 |
| 142 | -13.10556 | -18.19444 | 6.58358 |

## X, Y, and Z Coordinates of the Centroid of Aerodynamic Panels

| ELEM= | XPC | YPC | ZPC |
|---|---|---|---|
| 1 | .50055 | .06042 | .50538 |
| 2 | 2.50277 | .18125 | 1.51615 |
| 3 | 6.50719 | .30208 | 2.52691 |
| 4 | .50055 | .16506 | .36997 |
| 5 | 2.50277 | .49518 | 1.10990 |
| 6 | 6.50719 | .82531 | 1.84983 |
| 7 | .50055 | .22548 | .13542 |
| 8 | 2.50277 | .67643 | .40625 |
| 9 | 6.50719 | 1.12739 | .67708 |
| 10 | 10.51162 | .36250 | 2.97787 |
| 11 | 13.51434 | .36250 | 2.86901 |
| 12 | 16.51825 | .36250 | 2.76016 |
| 13 | 10.51162 | .99037 | 2.17995 |
| 14 | 13.51494 | .99037 | 2.10026 |
| 15 | 16.51825 | .99037 | 2.02058 |
| 16 | 10.51162 | 1.35287 | .79792 |
| 17 | 13.51494 | 1.35287 | .76875 |
| 18 | 16.51825 | 1.35287 | .73958 |
| 19 | 23.02545 | .30208 | 2.25478 |
| 20 | 31.03430 | .18125 | 1.35287 |
| 21 | 35.13872 | .06042 | .45096 |
| 22 | 23.02545 | .82531 | 1.65061 |
| 23 | 31.03430 | .49518 | .99037 |
| 24 | 35.13872 | .16506 | .33012 |
| 25 | 23.02545 | 1.12739 | .60417 |
| 26 | 31.03430 | .67643 | .36250 |
| 27 | 35.03872 | .22548 | .12083 |
| 28 | .50055 | .06042 | -.50538 |
| 29 | 2.50277 | .18125 | -1.51615 |
| 30 | 6.50719 | .30208 | -2.52691 |
| 31 | .50055 | .16506 | -.36997 |
| 32 | 2.50277 | .49518 | -1.10990 |
| 33 | 6.50719 | .82531 | -1.84983 |
| 34 | .50055 | .22548 | -.13542 |
| 35 | 2.50277 | .67643 | -.40625 |
| 36 | 6.50719 | 1.12739 | -.67708 |
| 37 | 10.51162 | .36250 | -2.97787 |
| 38 | 13.51494 | .36250 | -2.86901 |
| 39 | 16.51825 | .36250 | -2.76016 |
| 40 | 10.51162 | .99037 | -2.17995 |
| 41 | 13.51494 | .99037 | -2.10026 |
| 42 | 16.51825 | .99037 | -2.02058 |
| 43 | 10.51162 | 1.35287 | -.79792 |
| 44 | 13.51494 | 1.35297 | -.76875 |
| 45 | 16.51825 | 1.35287 | -.73958 |
| 46 | 23.02545 | .30208 | -2.25478 |
| 47 | 31.13430 | .18125 | -1.35287 |
| 48 | 35.03872 | .06042 | -.45096 |
| 49 | 23.02545 | .82531 | -1.65061 |

| | | | |
|---|---|---|---|
| 50 | 31.03430 | .49518 | -.99037 |
| 51 | 35.03872 | .16506 | -.33012 |
| 52 | 23.02545 | 1.12739 | -.60417 |
| 53 | 31.03430 | .67643 | -.36250 |
| 54 | 35.03872 | .22548 | -.12083 |
| 55 | .50055 | -.06042 | .50538 |
| 56 | 2.50277 | -.18125 | 1.51615 |
| 57 | 6.50719 | -.30208 | 2.52691 |
| 58 | .50055 | -.16506 | .36997 |
| 59 | 2.50277 | -.49518 | 1.10990 |
| 60 | 6.50719 | -.82531 | 1.84983 |
| 61 | .50055 | -.22548 | .13542 |
| 62 | 2.50277 | -.67643 | .40625 |
| 63 | 6.50719 | -1.12739 | .67708 |
| 64 | 10.51162 | -.36250 | 2.97787 |
| 65 | 13.51494 | -.36250 | 2.86901 |
| 66 | 16.51825 | -.36250 | 2.76016 |
| 67 | 10.51162 | -.99037 | 2.17995 |
| 68 | 13.51494 | -.99037 | 2.10026 |
| 69 | 16.51825 | -.99037 | 2.02058 |
| 70 | 10.51162 | -1.35297 | .79792 |
| 71 | 13.51494 | -1.35287 | .76875 |
| 72 | 16.51825 | -1.35297 | .73958 |
| 73 | 23.02545 | -.30208 | 2.25478 |
| 74 | 31.03430 | -.18125 | 1.35287 |
| 75 | 35.03872 | -.06042 | .45096 |
| 76 | 23.02545 | -.82531 | 1.65061 |
| 77 | 31.03430 | -.49518 | .99037 |
| 78 | 35.03872 | -.16506 | .33012 |
| 79 | 23.02545 | -1.12739 | .60417 |
| 80 | 31.03430 | -.67643 | .36250 |
| 81 | 35.03872 | -.22548 | .12083 |
| 82 | .50055 | -.06042 | -.50538 |
| 83 | 2.50277 | -.18125 | -1.51615 |
| 84 | 6.50719 | -.30208 | -2.52691 |
| 85 | .50055 | -.16506 | -.36997 |
| 86 | 2.50277 | -.49518 | -1.10990 |
| 87 | 6.50719 | -.82531 | -1.84983 |
| 88 | .50055 | -.22548 | -.13542 |
| 89 | 2.50277 | -.67643 | -.40625 |
| 90 | 6.50719 | -1.12739 | -.67708 |
| 91 | 10.51162 | -.36250 | -2.97787 |
| 92 | 13.51494 | -.36250 | -2.86901 |
| 93 | 16.51825 | -.36250 | -2.76016 |
| 94 | 10.51162 | -.99037 | -2.17995 |
| 95 | 13.51494 | -.99037 | -2.10026 |
| 96 | 16.51825 | -.99037 | -2.02058 |
| 97 | 10.51162 | -1.35287 | -.79792 |
| 98 | 13.51494 | -1.35297 | -.76875 |

| | | | |
|---|---|---|---|
| 99 | 16.01925 | -1.35287 | -.73358 |
| 100 | 23.12545 | -.30208 | -2.25479 |
| 101 | 31.13430 | -.18125 | -1.35287 |
| 102 | 35.13872 | -.06042 | -.45096 |
| 103 | 23.02545 | -.82531 | -1.65061 |
| 104 | 31.03430 | -.49518 | -.99037 |
| 105 | 35.03872 | -.16506 | -.33012 |
| 106 | 23.02545 | -1.12739 | -.60417 |
| 107 | 31.03430 | -.67643 | -.36250 |
| 108 | 35.03872 | -.22548 | -.12083 |
| 109 | 11.75744 | 8.26389 | 6.68731 |
| 110 | 12.53608 | 8.26389 | 6.73052 |
| 111 | 14.19335 | 8.26389 | 6.71321 |
| 112 | 11.75744 | 15.48611 | 6.68731 |
| 113 | 12.53608 | 15.48611 | 6.73052 |
| 114 | 14.09335 | 15.48611 | 6.71321 |
| 115 | 11.75744 | 19.09722 | 6.67866 |
| 116 | 12.53608 | 19.09722 | 6.70026 |
| 117 | 14.19335 | 19.09722 | 6.69161 |
| 118 | 11.75744 | 8.26389 | 6.65269 |
| 119 | 12.53608 | 8.26389 | 6.60348 |
| 120 | 14.09335 | 8.26389 | 6.62679 |
| 121 | 11.75744 | 15.48611 | 6.65269 |
| 122 | 12.53608 | 15.48611 | 6.60948 |
| 123 | 14.09335 | 15.48611 | 6.62679 |
| 124 | 11.75744 | 19.09722 | 6.66134 |
| 125 | 12.53608 | 19.09722 | 6.63974 |
| 126 | 14.19335 | 19.09722 | 6.64839 |
| 127 | -11.75744 | -8.26389 | 6.68731 |
| 128 | -12.53608 | -8.26389 | 6.73052 |
| 129 | -14.09335 | -8.26389 | 6.71321 |
| 130 | -11.75744 | -15.48611 | 6.68731 |
| 131 | -12.53608 | -15.48611 | 6.73052 |
| 132 | -14.09335 | -15.48611 | 6.71321 |
| 133 | -11.75744 | -19.09722 | 6.67866 |
| 134 | -12.53608 | -19.09722 | 6.70026 |
| 135 | -14.09335 | -19.09722 | 6.69161 |
| 136 | -11.75744 | -8.26389 | 6.65269 |
| 137 | -12.53608 | -8.26389 | 6.60948 |
| 138 | -14.09335 | -8.26399 | 6.62679 |
| 139 | -11.75744 | -15.48611 | 6.65269 |
| 140 | -12 53608 | -15.48611 | 6.60948 |
| 141 | -14.09335 | -15.48611 | 6.62679 |
| 142 | -11.75744 | -19.09722 | 6.66134 |
| 143 | -12.53608 | -19.09722 | 6.63974 |
| 144 | -14.09335 | -19.09722 | 6.64839 |

## Nodal Numbering for Surfaces

FOR SURFACE 1

| | | | |
|---|---|---|---|
| 1 | 1 | 1 | 1 |
| 2 | 5 | 8 | 11 |
| 3 | 6 | 9 | 12 |
| 4 | 7 | 10 | 13 |

FOR SURFACE 2

| | | | |
|---|---|---|---|
| 4 | 7 | 10 | 13 |
| 14 | 17 | 20 | 23 |
| 15 | 18 | 21 | 24 |
| 16 | 19 | 22 | 25 |

FOR SURFACE 3

| | | | |
|---|---|---|---|
| 16 | 19 | 22 | 25 |
| 26 | 29 | 31 | 33 |
| 27 | 30 | 32 | 34 |
| 23 | 28 | 28 | 28 |

FOR SURFACE 5

| | | | |
|---|---|---|---|
| 1 | 1 | 1 | 1 |
| 35 | 38 | 41 | 11 |
| 36 | 39 | 42 | 12 |
| 37 | 40 | 43 | 13 |

FOR SURFACE 6

| | | | |
|---|---|---|---|
| 37 | 40 | 43 | 13 |
| 44 | 47 | 50 | 23 |
| 45 | 48 | 51 | 24 |
| 46 | 49 | 52 | 25 |

FOR SURFACE 7

| | | | |
|---|---|---|---|
| 46 | 49 | 52 | 25 |
| 53 | 55 | 57 | 33 |
| 54 | 56 | 58 | 34 |
| 23 | 28 | 28 | 28 |

FOR SURFACE 9

| | | | |
|---|---|---|---|
| 1 | 1 | 1 | 1 |
| 2 | 59 | 62 | 65 |
| 3 | 60 | 63 | 66 |
| 4 | 61 | 64 | 67 |

FOR SURFACE 10

| | | | |
|---|---|---|---|
| 4 | 61 | 64 | 67 |
| 14 | 58 | 71 | 74 |
| 15 | 69 | 72 | 75 |
| 16 | 70 | 73 | 76 |

FOR SURFACE 11

| | | | |
|---|---|---|---|
| 16 | 70 | 73 | 76 |
| 26 | 77 | 79 | 81 |
| 27 | 78 | 80 | 82 |
| 28 | 28 | 28 | 28 |

FOR SURFACE 13

| | | | |
|---|---|---|---|
| 1 | 1 | 1 | 1 |
| 35 | 83 | 86 | 65 |
| 36 | 84 | 87 | 66 |
| 37 | 85 | 88 | 67 |

FOR SURFACE 14

| | | | |
|---|---|---|---|
| 37 | 85 | 88 | 67 |
| 44 | 89 | 92 | 74 |
| 45 | 90 | 93 | 75 |
| 46 | 91 | 94 | 76 |

FOR SURFACE 15

| | | | |
|---|---|---|---|
| 46 | 91 | 94 | 76 |
| 53 | 95 | 97 | 81 |
| 54 | 96 | 98 | 82 |
| 28 | 28 | 28 | 28 |

FOR SURFACE 24

| | | | |
|---|---|---|---|
| 99 | 103 | 107 | 111 |
| 100 | 104 | 108 | 112 |
| 101 | 105 | 109 | 113 |
| 102 | 106 | 110 | 114 |

FOR SURFACE 25

| | | | |
|---|---|---|---|
| 99 | 103 | 107 | 111 |
| 115 | 117 | 119 | 112 |
| 116 | 118 | 120 | 113 |
| 102 | 106 | 110 | 114 |

FOR SURFACE 27

| | | | |
|---|---|---|---|
| 121 | 125 | 129 | 133 |
| 122 | 126 | 130 | 134 |
| 123 | 127 | 131 | 135 |
| 124 | 128 | 132 | 136 |

FOR SURFACE 28

| | | | |
|---|---|---|---|
| 121 | 125 | 129 | 133 |
| 137 | 139 | 141 | 134 |
| 138 | 140 | 142 | 135 |
| 124 | 128 | 132 | 136 |

# Nodal Numbering for Elements

| ELEM | ++ | +- | -+ | -- |
|---|---|---|---|---|
| 1 | 5 | 2 | 1 | 1 |
| 2 | 6 | 3 | 5 | 2 |
| 3 | 7 | 4 | 6 | 3 |
| 4 | 8 | 5 | 1 | 1 |
| 5 | 9 | 6 | 8 | 5 |
| 6 | 10 | 7 | 9 | 6 |
| 7 | 11 | 8 | 1 | 1 |
| 8 | 12 | 9 | 11 | 8 |
| 9 | 13 | 10 | 12 | 9 |
| 10 | 17 | 14 | 7 | 4 |
| 11 | 18 | 15 | 17 | 14 |
| 12 | 19 | 16 | 18 | 15 |
| 13 | 20 | 17 | 18 | 7 |
| 14 | 21 | 18 | 20 | 17 |
| 15 | 22 | 19 | 21 | 18 |
| 16 | 23 | 20 | 13 | 10 |
| 17 | 24 | 21 | 23 | 20 |
| 18 | 25 | 22 | 24 | 21 |
| 19 | 29 | 26 | 19 | 16 |
| 20 | 30 | 27 | 29 | 26 |
| 21 | 28 | 28 | 30 | 27 |
| 22 | 31 | 29 | 22 | 19 |
| 23 | 32 | 30 | 31 | 29 |
| 24 | 28 | 28 | 32 | 30 |
| 25 | 33 | 31 | 25 | 22 |
| 26 | 34 | 32 | 33 | 31 |
| 27 | 28 | 28 | 34 | 32 |
| 28 | 35 | 38 | 1 | 1 |
| 29 | 36 | 39 | 35 | 38 |
| 30 | 37 | 40 | 36 | 39 |
| 31 | 38 | 41 | 1 | 1 |
| 32 | 39 | 42 | 38 | 41 |
| 33 | 40 | 43 | 39 | 42 |
| 34 | 41 | 11 | 1 | 1 |
| 35 | 42 | 12 | 41 | 11 |
| 36 | 43 | 13 | 42 | 12 |
| 37 | 44 | 47 | 37 | 40 |
| 38 | 45 | 48 | 44 | 47 |
| 39 | 46 | 49 | 45 | 48 |
| 40 | 47 | 50 | 40 | 43 |
| 41 | 48 | 51 | 47 | 50 |
| 42 | 49 | 52 | 48 | 51 |
| 43 | 50 | 23 | 43 | 13 |
| 44 | 51 | 24 | 50 | 23 |
| 45 | 52 | 25 | 51 | 24 |
| 46 | 53 | 55 | 46 | 49 |
| 47 | 54 | 56 | 53 | 55 |
| 48 | 28 | 28 | 54 | 56 |

| | | | | |
|---|---|---|---|---|
| 49 | 55 | 57 | 49 | 52 |
| 50 | 56 | 58 | 55 | 57 |
| 51 | 28 | 28 | 56 | 58 |
| 52 | 57 | 33 | 52 | 25 |
| 53 | 58 | 34 | 57 | 33 |
| 54 | 28 | 28 | 58 | 34 |
| 55 | 2 | 59 | 1 | 1 |
| 56 | 3 | 60 | 2 | 59 |
| 57 | 4 | 61 | 3 | 60 |
| 58 | 59 | 62 | 1 | 1 |
| 59 | 60 | 63 | 59 | 62 |
| 60 | 61 | 64 | 60 | 63 |
| 61 | 52 | 65 | 1 | 1 |
| 62 | 63 | 66 | 62 | 65 |
| 63 | 64 | 67 | 63 | 66 |
| 64 | 14 | 68 | 4 | 61 |
| 65 | 15 | 69 | 14 | 68 |
| 66 | 16 | 70 | 15 | 69 |
| 67 | 68 | 71 | 61 | 64 |
| 68 | 69 | 72 | 58 | 71 |
| 69 | 70 | 73 | 69 | 72 |
| 70 | 71 | 74 | 64 | 67 |
| 71 | 12 | 75 | 71 | 74 |
| 72 | 73 | 76 | 72 | 75 |
| 73 | 26 | 77 | 16 | 70 |
| 74 | 27 | 78 | 26 | 77 |
| 75 | 28 | 28 | 27 | 78 |
| 76 | 17 | 79 | 70 | 73 |
| 77 | 78 | 80 | 77 | 79 |
| 79 | 28 | 28 | 78 | 80 |
| 79 | 79 | 81 | 73 | 76 |
| 80 | 80 | 62 | 79 | 81 |
| 81 | 28 | 28 | 80 | 82 |
| 82 | 83 | 35 | 1 | 1 |
| 83 | 84 | 36 | 83 | 35 |
| 84 | 85 | 37 | 84 | 36 |
| 85 | 86 | 83 | 1 | 1 |
| 86 | 87 | 84 | 86 | 83 |
| 87 | 88 | 85 | 87 | 84 |
| 88 | 65 | 86 | 1 | 1 |
| 89 | 56 | 87 | 65 | 86 |
| 90 | 67 | 88 | 66 | 87 |
| 91 | 89 | 44 | 85 | 37 |
| 92 | 30 | 45 | 89 | 44 |
| 93 | 41 | 46 | 90 | 45 |
| 94 | 92 | 89 | 88 | 85 |
| 95 | 43 | 90 | 32 | 89 |
| 96 | 94 | 91 | 93 | 90 |

| | | | | |
|---|---|---|---|---|
| 97 | 74 | 92 | 67 | 88 |
| 98 | 75 | 93 | 74 | 92 |
| 99 | 76 | 94 | 75 | 93 |
| 100 | 95 | 53 | 91 | 46 |
| 101 | 96 | 54 | 95 | 53 |
| 102 | 28 | 28 | 96 | 54 |
| 103 | 97 | 95 | 94 | 91 |
| 104 | 98 | 96 | 97 | 95 |
| 105 | 28 | 28 | 98 | 96 |
| 106 | 81 | 97 | 76 | 94 |
| 107 | 82 | 98 | 81 | 97 |
| 108 | 28 | 28 | 82 | 98 |
| 109 | 104 | 100 | 103 | 99 |
| 110 | 105 | 101 | 104 | 100 |
| 111 | 106 | 102 | 105 | 101 |
| 112 | 108 | 104 | 107 | 103 |
| 113 | 109 | 105 | 108 | 104 |
| 114 | 110 | 106 | 109 | 105 |
| 115 | 112 | 108 | 111 | 107 |
| 116 | 113 | 109 | 112 | 108 |
| 117 | 114 | 110 | 113 | 109 |
| 118 | 115 | 117 | 99 | 103 |
| 119 | 116 | 118 | 115 | 117 |
| 120 | 102 | 106 | 116 | 118 |
| 121 | 117 | 119 | 103 | 107 |
| 122 | 118 | 120 | 117 | 119 |
| 123 | 106 | 110 | 118 | 120 |
| 124 | 119 | 112 | 107 | 111 |
| 125 | 120 | 113 | 119 | 112 |
| 126 | 110 | 114 | 120 | 113 |
| 127 | 126 | 122 | 125 | 121 |
| 128 | 127 | 123 | 126 | 122 |
| 129 | 128 | 124 | 127 | 123 |
| 130 | 130 | 126 | 129 | 125 |
| 131 | 131 | 127 | 130 | 126 |
| 132 | 132 | 128 | 131 | 127 |
| 133 | 134 | 130 | 133 | 129 |
| 134 | 135 | 131 | 134 | 130 |
| 135 | 136 | 132 | 135 | 131 |
| 136 | 137 | 139 | 121 | 125 |
| 137 | 138 | 140 | 137 | 139 |
| 138 | 124 | 128 | 138 | 140 |
| 139 | 139 | 141 | 125 | 129 |
| 140 | 140 | 142 | 139 | 141 |
| 141 | 128 | 132 | 140 | 142 |
| 142 | 141 | 134 | 129 | 133 |
| 143 | 142 | 135 | 141 | 134 |
| 144 | 132 | 136 | 142 | 135 |

## The Distribution of the Source

FOR SUBSURFACE 1

| | | |
|---|---|---|
| -.89735E+02 | -.89462E+02 | -.89131E+02 |
| -.84927E+02 | -.84701E+02 | -.84594E+02 |
| -.74571E+02 | -.74839E+02 | -.74282E+02 |

FOR SUBSURFACE 2

| | | |
|---|---|---|
| -.47538E+02 | -.49261E+02 | -.48983E+02 |
| -.27588E+02 | -.28720E+02 | -.30053E+02 |
| -.11036E+02 | -.11957E+02 | -.14521E+02 |

FOR SUBSURFACE 3

| | | |
|---|---|---|
| .75639E+01 | .69589E+01 | .54540E+01 |
| .13044E+02 | .13474E+02 | .12748E+02 |
| .16507E+02 | .16315E+02 | .15939E+02 |

FOR SUBSURFACE 5

| | | |
|---|---|---|
| -.89536E+02 | -.89490E+02 | -.89141E+02 |
| -.84723E+02 | -.84573E+02 | -.84537E+02 |
| -.72623E+02 | -.72787E+02 | -.73400E+02 |

FOR SUBSURFACE 6

| | | |
|---|---|---|
| -.42652E+02 | -.44604E+02 | -.47102E+02 |
| -.29142E+02 | -.29854E+02 | -.30444E+02 |
| -.18342E+02 | -.17929E+02 | -.16805E+02 |

FOR SUBSURFACE 7

| | | |
|---|---|---|
| .10734E+01 | .20296E+01 | .35994E+01 |
| .10713E+02 | .11148E+02 | .11893E+02 |
| .15577E+02 | .15562E+02 | .15663E+02 |

FOR SUBSURFACE 9

| | | |
|---|---|---|
| -.89783E+02 | -.89429E+02 | -.89089E+02 |
| -.84634E+02 | -.84210E+02 | -.84007E+02 |
| -.73652E+02 | -.72497E+02 | -.71870E+02 |

FOR SUBSURFACE 10

| | | |
|---|---|---|
| -.46084E+02 | -.46123E+02 | -.46406E+02 |
| -.27741E+02 | -.29056E+02 | -.30431E+02 |
| -.12367E+02 | -.14895E+02 | -.17301E+02 |

FOR SUBSURFACE 11

| | | |
|---|---|---|
| .70612E+01 | .56619E+01 | .38513E+01 |
| .13799E+02 | .13237E+02 | .12415E+02 |
| .16538E+02 | .16263E+02 | .15865E+02 |

FOR SUBSURFACE 13

| | | |
|---|---|---|
| -.89925E+02 | -.89462E+02 | -.89100E+02 |
| -.84622E+02 | -.84266E+02 | -.84043E+02 |
| -.72382E+02 | -.71951E+02 | -.71744E+02 |

FOR SUBSURFACE 14

| | | |
|---|---|---|
| -.42542E+02 | -.44103E+02 | -.45755E+02 |
| -.29317E+02 | -.30195E+02 | -.30847E+02 |
| -.18708E+02 | -.19042E+02 | -.18739E+02 |

FOR SUBSURFACE 15

| | | |
|---|---|---|
| .74244E+00 | .10670E+01 | .21658E+01 |
| .10617E+02 | .10890E+02 | .11551E+02 |
| .15596E+02 | .15506E+02 | .15589E+02 |

FOR SJBSURFACE 24

| | | |
|---|---|---|
| -.38755E+03 | -.70861E+03 | -.62415E+03 |
| -.26131E+03 | -.48756E+03 | -.61629E+03 |
| .23480E+03 | .40777E+03 | -.42148E+02 |

FOR SUBSURFACE 25

| | | |
|---|---|---|
| -.38756E+03 | -.70861E+03 | -.62415E+03 |
| -.26133E+03 | -.48756E+03 | -.61628E+03 |
| .23479E+03 | .40777E+03 | -.42148E+02 |

FOR SJBSURFACE 27

| | | |
|---|---|---|
| -.37486E+03 | -.69827E+03 | -.61925E+03 |
| -.25512E+03 | -.48144E+03 | -.61353E+03 |
| .22337E+03 | .39747E+03 | -.48037E+02 |

FOR SUBSURFACE 28

| | | |
|---|---|---|
| -.37616E+03 | -.69828E+03 | -.61925E+03 |
| -.25513E+03 | -.48144E+03 | -.61353E+03 |
| .22396E+03 | .39747E+03 | -.48039E+02 |

## The Distribution of the Velocity Potential

FOR SUBSURFACE 1

| | | |
|---|---|---|
| -.46059E+02 | -.45837E+02 | -.45642E+02 |
| -.43304E+02 | -.43535E+02 | -.43832E+02 |
| -.38208E+02 | -.39314E+02 | -.39933E+02 |

FOR SUBSURFACE 2

| | | |
|---|---|---|
| -.20751E+02 | -.23836E+02 | -.25505E+02 |
| -.96652E+01 | -.11712E+02 | -.15051E+02 |
| .59479E+01 | .58202E+01 | .19663E+01 |

FOR SUBSURFACE 3

| | | |
|---|---|---|
| -.10816E+03 | -.10755E+03 | -.81939E+02 |
| -.50172E+03 | -.35260E+03 | -.23162E+03 |
| -.28712E+03 | -.26490E+03 | -.23473E+03 |

FOR SUBSURFACE 5

| | | |
|---|---|---|
| -.46449E+02 | -.46103E+02 | -.45735E+02 |
| -.44549E+02 | -.44330E+02 | -.44107E+02 |
| -.40363E+02 | -.40151E+02 | -.40099E+02 |

FOR SUBSURFACE 6

| | | |
|---|---|---|
| -.24928E+02 | -.25525E+02 | -.25893E+02 |
| -.20842E+02 | -.20185E+02 | -.18347E+02 |
| -.17573E+02 | -.14880E+02 | -.10502E+02 |

FOR SUBSURFACE 7

| | | |
|---|---|---|
| -.46017E+02 | -.51944E+02 | -.60332E+02 |
| -.11458E+03 | -.12857E+03 | -.16635E+03 |
| -.17639E+03 | -.18723E+03 | -.20720E+03 |

FOR SUBSURFACE 9

| | | |
|---|---|---|
| -.46016E+02 | -.45697E+02 | -.45459E+02 |
| -.42909E+02 | -.42573E+02 | -.42661E+02 |
| -.36572E+02 | -.35876E+02 | -.36314E+02 |

FOR SUBSURFACE 10

| | | |
|---|---|---|
| -.18657E+02 | -.19743E+02 | -.22044E+02 |
| -.96158E+01 | -.12030E+02 | -.15413E+02 |
| .41598E+01 | .20712E+01 | -.17663E+01 |

FOR SUBSURFACE 11

| | | |
|---|---|---|
| -.10339E+03 | -.10960E+03 | -.84478E+02 |
| -.50095E+03 | -.35293E+03 | -.23248E+03 |
| -.28715E+03 | -.26507E+03 | -.23491E+03 |

FOR SUBSURFACE 13

| | | |
|---|---|---|
| -.46401E+02 | -.45972E+02 | -.45552E+02 |
| -.44297E+02 | -.43636E+02 | -.43068E+02 |
| -.39862E+02 | -.38630E+02 | -.37418E+02 |

FOR SUBSURFACE 14

| | | |
|---|---|---|
| -.24681E+02 | -.24636E+02 | -.23897E+02 |
| -.21048E+02 | -.20633E+02 | -.18770E+02 |
| -.18526E+02 | -.16667E+02 | -.13421E+02 |

| | | |
|---|---|---|
| FOR SUBSURFACE 15 | | |
| -.46536E+02 | -.53579E+02 | -.62687E+02 |
| -.11372E+03 | -.12969E+03 | -.16479E+03 |
| -.17643E+03 | -.18733E+03 | -.20732E+03 |
| FOR SUBSURFACE 24 | | |
| -.19908E+03 | -.36608E+03 | -.31439E+03 |
| -.13739E+03 | -.26042E+03 | -.31484E+03 |
| .13121E+03 | .22146E+03 | -.16831E+02 |
| FOR SUBSURFACE 25 | | |
| -.20891E+03 | -.36731E+03 | -.31523E+03 |
| -.14058E+03 | -.26242E+03 | -.31620E+03 |
| .12759E+03 | .21921E+03 | -.17550E+02 |
| FOR SUBSURFACE 27 | | |
| -.19701E+03 | -.36264E+03 | -.31327E+03 |
| -.13848E+03 | -.25951E+03 | -.31511E+03 |
| .11989E+03 | .21306E+03 | -.21094E+02 |
| FOR SUBSURFACE 28 | | |
| -.19725E+03 | -.36280E+03 | -.31340E+03 |
| -.13894E+03 | -.25976E+03 | -.31532E+03 |
| .11955E+03 | .21280E+03 | -.21302E+02 |

# Pressure Distribution

FOR SUBSURFACE 1

| | | |
|---|---|---|
| .16033E+01 | .12491E+01 | .13863E+01 |
| .47196E+00 | -.37578E-01 | -.35702E-01 |
| -.75973E-01 | -.71136E-01 | -.69669E-01 |

FOR SUBSURFACE 2

| | | |
|---|---|---|
| -.17921E+00 | -.17405E+00 | -.15750E+00 |
| -.16858E+00 | -.18174E+00 | -.15948E+00 |
| .62216E+00 | .56760E+00 | .43089E+00 |

FOR SUBSURFACE 3

| | | |
|---|---|---|
| .91196E+00 | .75819E+00 | .48350E+00 |
| .73212E+00 | .86923E+00 | .57373E+00 |
| -.15581E+01 | .89266E-01 | .15728E+00 |

FOR SUBSURFACE 5

| | | |
|---|---|---|
| .92646E+00 | .12525E+01 | .13879E+01 |
| -.35608E-01 | -.38367E-01 | -.36135E-01 |
| -.70634E-01 | -.70751E-01 | -.69486E-01 |

FOR SUBSURFACE 6

| | | |
|---|---|---|
| -.12349E+00 | -.12867E+00 | -.13994E+00 |
| -.48501E-01 | -.68291E-01 | -.10844E+00 |
| .17198E+00 | .20744E+00 | .28982E+00 |

FOR SUBSURFACE 7

| | | |
|---|---|---|
| .18416E+00 | .21073E+00 | .30861E+00 |
| .38039E+00 | .34409E+00 | .40358E+00 |
| .11380E+01 | .73242E+00 | .39221E+00 |

FOR SUBSURFACE 9

| | | |
|---|---|---|
| .17926E+01 | .12271E+01 | .13663E+01 |
| .45358E+00 | -.59901E-01 | -.55051E-01 |
| -.89829E-01 | -.83759E-01 | -.77312E-01 |

FOR SUBSURFACE 10

| | | |
|---|---|---|
| -.16893E+00 | -.15273E+00 | -.13413E+00 |
| -.14938E+00 | -.13943E+00 | -.11648E+00 |
| .52453E+00 | .57705E+00 | .44364E+00 |

FOR SUBSURFACE 11

| | | |
|---|---|---|
| .91496E+00 | .75143E+00 | .47793E+00 |
| .72772E+00 | .86170E+00 | .56648E+00 |
| -.15614E+01 | .81267E-01 | .15053E+00 |

FOR SUBSURFACE 13

| | | |
|---|---|---|
| .91495E+00 | .12334E+01 | .13684E+01 |
| -.44118E-01 | -.52030E-01 | -.52583E-01 |
| -.74141E-01 | -.75231E-01 | -.74709E-01 |

FOR SUBSURFACE 14

| | | |
|---|---|---|
| -.11879E+00 | -.11590E+00 | -.12045E+00 |
| -.43102E-01 | -.50677E-01 | -.77182E-01 |
| .17265E+00 | .21433E+00 | .30114E+00 |

| | | |
|---|---|---|
| FOR SUBSURFACE 15 | | |
| .18181E+00 | .20744E+00 | .29630E+00 |
| .37629E+00 | .33818E+00 | .33673E+00 |
| .11291E+01 | .72403E+00 | .38526E+00 |
| FOR SUBSURFACE 24 | | |
| -.24559E+03 | -.41632E+03 | -.15643E+03 |
| -.40284E+03 | -.87233E+03 | -.90483E+03 |
| -.17987E+03 | -.47176E+03 | -.66969E+03 |
| FOR SUBSURFACE 25 | | |
| -.23212E+03 | -.39809E+03 | -.14613E+03 |
| -.40121E+03 | -.86989E+03 | -.90090E+03 |
| -.18330E+03 | -.47636E+03 | -.67019E+03 |
| FOR SUBSURFACE 27 | | |
| -.22548E+03 | -.39161E+03 | -.14203E+03 |
| -.37732E+03 | -.83780E+03 | -.87553E+03 |
| -.16408E+03 | -.45538E+03 | -.65340E+03 |
| FOR SUBSURFACE 28 | | |
| -.22392E+03 | -.38923E+03 | -.14061E+03 |
| -.37720E+03 | -.83759E+03 | -.87504E+03 |
| -.16944E+03 | -.45653E+03 | -.65346E+03 |

## SECTION 6

## PROGRAM LISTING

```
      PROGRAM MAIN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
C
C
C     NS(MAX)=34
C     NELEM(MAX)=400
C     NNODE(MAX)=350
      COMMON/ZZZ1/NX(34),NY(34),NXY(34),KSYMMY,KSYMMZ,NSYMMY,NSYMMZ
      COMMON/ZZZ2/NSEX,NSBODY,NS,NT(34),ISFACE(34),KNORML(34),KWAKES(34)
      COMMON/ZZZ3/NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,NSHAFT,NHUB,NSHANK,
     1 NBLADE
      COMMON/ZZZ4/UMACH,OMEGA,ALFA,ABETA,AREA
      COMMON/ZZZ5/XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      COMMON/ZZZ6/XNOSE,XBD1,XBD2,XTAIL
      COMMON/ZZZ7/YNOSE,YBD1,YBD2,YTAIL
      COMMON/ZZZ8/ZNOSE,ZBD1,ZBD2,ZTAIL
      COMMON/ZZZ9/RYBD1,RZBD1,RYBD2,RZBD2
      COMMON/ZZZ10/RSHAFT,LSHAFT,RSHANK,LSHANK
      COMMON/ZZZ11/XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
      COMMON/ZZZ12/RROTOR,BCHORD,TAUBL,ALFAB
      COMMON/ZZZ13/THET75,THET1C,THET1S,CONING,AZIMUTH
      COMMON/ZZZ14/KBLADE,TANLEB,TANTEB,XBLE,XBTE,KROTORS(34)
      COMMON/ZZZ15/NSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAU,ZVTAIL
      COMMON/ZZZ16/NWAKPY,NWAKHB,NWAKSK,NWAKBL
      COMMON/ZZZ17/WAKLPY,WAKLHB,WAKLSK,WAKLBL
      COMMON/ZZZ18/WANGPY,WANGHB,WANGSK,WANGBL
      COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
      COMMON/ZZZ20/PI
      COMMON/ZZZ21/KPY1,KPY2
      COMMON/ZZZ22/KNSELE,KNSSHP,KNSTYP
      COMMON/ZZZ23/KBDELE,KBDSHP,KBDTYP
      COMMON/ZZZ24/KTNELE,KTNSHP,KTNTYP
      COMMON/ZZZ25/KPYELE,KPYSHP,KPYTYP
      COMMON/ZZZ26/KVTELE,KVTSHP,KVTTYP
      COMMON/ZZZ27/KSHELE,KSHSHP,KSHTYP
      COMMON/ZZZ28/KHBELE,KHBSHP,KHBTYP
      COMMON/ZZZ29/KSKELE,KSKSHP,KSKTYP
      COMMON/ZZZ30/KBLELE,KBLSHP,KBLTYP
      COMMON/ZZZ31/NSTAG,NVORT,NSPIRAL,SPIRAL
      COMMON/ZZZ32/CSTAG,CVORT
      COMMON/ZZZ33/UWAKE
      COMMON/ZZZ34/YCUT
      COMMON/ZZZ35/ITWIST,RPITCH,TWIST
      COMMON/ZZZ50/XCTR,YCTR,ZCTR,RX,RY,RZ
      COMMON/ZZZ51/NSPAN,XLEZH,XTEZH,TANLEH,TANTEH,TAUH,ZP
      DIMENSION VELY(250),VELZ(250),PHI3(250),KROTOR(250)
      DIMENSION CP(250),VELX(250),GG(2),AVG(250)
      DIMENSION PC(3,250),P1(3,250),P2(3,250),P3(3,250),XK(3,250)
      DIMENSION KWAKE(250),NODE(4,250),NOFCT(40,34)
      DIMENSION PHIC(250),PHI1(250),PHI2(250),BC(250)
      DIMENSION AA(62500),SOURCE(250),SOR(250)
      EQUIVALENCE (AA(1),PHIC(1)),(AA(401),PHI1(1))
      EQUIVALENCE (AA(801),PHI2(1)),(AA(1201),PHI3(1))
      EQUIVALENCE (AA(1601),VELX(1)),(AA(2001),VELY(1))
      EQUIVALENCE (AA(2401),VELZ(1)),(AA(2801),CP(1))
      REAL LSHAFT,LSHANK
C
      NREAD=5
```

```
      NWRITE=6
      NXMAX=6
      NYMAX=6
      NTMAX=400
      NXMAXP=NXMAX+1
      NYMAXP=NYMAX+1
      NXYMP=NXMAXP*NYMAXP
      NSTAG=0
      NVORT=0
      NSPIRAL=0
      NWAKBL=0
C
      READ(NREAD,2) NCASE
      WRITE(NWRITE,2)NCASE
    2 FORMAT(10I5)
    3 FORMAT(10F8.3)
    4 FORMAT(2A4,2I5)
C
      DO 999 ICASE=1,NCASE
C
C
      CALL DATA(NELEM)
C
      CALL REFFRO(NNODE,NXYMP,NOFCT,NELEM,NTWAKE)
C
      CALL COORT(NELEM,NXYMP,NOFCT,XK,NNODE)
C
      CALL CHECK(NELEM,NXMAX,NYMAX,NTMAX)
C
      CALL GEOMET(NELEM,NXYMP,NOFCT,NODE,XK,NNODE,KWAKE,KROTOR)
      WRITE(6,60)
   60 FORMAT(10X,*--- MAIN FROM GEOMAT ---*)
C
      IF(KPRINT(1).EQ.1)
     1 CALL PRINTA(NELEM,NXYMP,XK,NNODE,PC,NOFCT,NODE,1)
C
      IF(KPRINT(2).EQ.1)
     1CALL PRINTA(NELEM,NXYMP,XK,NNODE,PC,NOFCT,NODE,2)
C
      CALL VEC123(NELEM,NODE,PC,P1,P2,P3,XK,NNODE)
C
      IF(KPRINT(3).EQ.1)
     1CALL PRINTA(NELEM,NXYMP,XK,NNODE,PC,NOFCT,NODE,3)
C
      IF (KPRINT(4).EQ.1)
     1CALL PRINTA(NELEM,NXYMP,XK,NNODE,PC,NOFCT,NODE,4)
C
      NESQ=NELEM**2
C
      DO 6 NN=1,NESQ
      AA(NN)=0.0
    6 CONTINUE
C
      DO 8 I=1,NELEM
      NNN=I+(I-1)*NELEM
      SOURCE(I)=0.0
      AA(NNN)=1.0
```

```
      9 CONTINUE
C
        CALL  COEFF(NELEM,PC,NNODE,XK,NODE,KWAKE,NESQ,AA,SOURCE,BC,
       1 KROTOR,1)
C
        IF(NSTAG.NE.0)
       1 CALL  COEFF(NELEM,PC,NNODE,XK,NODE,KWAKE,NESQ,AA,SOURCE,BC,
       2 KROTOR,2)
C
        IF(NVORT.NE.0)
       1 CALL  COEFF(NELEM,PC,NNODE,XK,NODE,KWAKE,NESQ,AA,SOURCE,BC,
       2 KROTOR,3)
C
        IF(NBLADE.EQ.1 .AND. NWAKBL.NE.0)
       1 CALL  COEFF(NELEM,PC,NNODE,XK,NODE,KWAKE,NESQ,AA,SOURCE,BC,
       2 KROTOR,4)
C
        IF(KPRINT(5).EQ.1)CALL  PRINTB(NELEM,NESQ,AA,SOURCE,1)
C
        IF(KPRINT(6).EQ.1)CALL  PRINTB(NELEM,NESQ,AA,SOURCE,2)
C
        CALL  SOLUTN(NELEM,NESQ,AA,SOURCE)
C
        IF(KPRINT(7).EQ.1)CALL  PRINTB(NELEM,NESQ,AA,SOURCE,3)
C
        CALL  AVERAG(SOURCE,SOR,CC,NELEM,NODE,NOECT,MXYMP,NNODE,AVG)
C
        CALL  PHI(SOR,NNODE,NODE,PHIC,PHI1,PHI2,PHI3,NELEM)
C
        CALL  VELXYZ(VELX,VELY,VELZ,PHI1,PHI2,PHI3,PC,P1,P2,P3,NELEM)
C
        CALL  CPLINR(CP,VELX,VELY,VELZ,PHIC,NELEM,PC,KROTOR)
C
        IF(KPRINT(8).EQ.1)CALL  PRINTB(NELEM,NESQ,AA,CP,4)
C
        CALL  FORCE(NNODE,XK,NELEM,NODE,CP)
C
    999 CONTINUE
   1000 STOP
        END
```

```
C
      SUBROUTINE DATA(NELEM)
C
C
C     DATE CREATED :   MARCH 31, 1975
C
      COMMON/ZZZ1/NX(34),NY(34),NXY(34),KSYMMY,KSYMMZ,NSYMMY,NSYMMZ
      COMMON/ZZZ2/NSEX,NSBODY,NS,NT(34),ISFACE(34),KNORML(34),KWAKES(34)
      COMMON/ZZZ3/NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,NSHAFT,NHUB,NSHANK,
     1 NBLADE
      COMMON/ZZZ4/UMACH,OMEGA,ALFA,ABETA
      COMMON/ZZZ5/XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      COMMON/ZZZ6/XNOSE,XBD1,XBD2,XTAIL
      COMMON/ZZZ7/YNOSE,YBD1,YBD2,YTAIL
      COMMON/ZZZ8/ZNOSE,ZBD1,ZBD2,ZTAIL
      COMMON/ZZZ9/RYBD1,RZBD1,RYBD2,RZBD2
      COMMON/ZZZ10/RSHAFT,LSHAFT,RSHANK,LSHANK
      COMMON/ZZZ11/XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
      COMMON/ZZZ12/RROTOR,BCHORD,TAUBL,ALFAB
      COMMON/ZZZ13/THET75,THET1C,THET1S,CONING,AZIMUTH
      COMMON/ZZZ14/KBLADE,TANLEB,TANTEB,XBLE,XBTE,KROTORS(34)
      COMMON/ZZZ15/VSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAU,ZVTAIL
      COMMON/ZZZ16/NWAKPY,NWAKHB,NWAKSK,NWAKBL
      COMMON/ZZZ17/WAKLPY,WAKLHB,WAKLSK,WAKLBL
      COMMON/ZZZ18/WANGPY,WANGHB,WANGSK,WANGBL
      COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
      COMMON/ZZZ20/PI
      COMMON/ZZZ21/KPY1,KPY2
      COMMON/ZZZ22/KNSELE,KNSSHP,KNSTYP
      COMMON/ZZZ23/KBDELE,KBDSHP,KBDTYP
      COMMON/ZZZ24/KTNELE,KTNSHP,KTNTYP
      COMMON/ZZZ25/KPYELE,KPYSHP,KPYTYP
      COMMON/ZZZ26/KVTELE,KVTSHP,KVTTYP
      COMMON/ZZZ27/KSHELE,KSHSHP,KSHTYP
      COMMON/ZZZ28/KHBELE,KHBSHP,KHBTYP
      COMMON/ZZZ29/KSKELE,KSKSHP,KSKTYP
      COMMON/ZZZ30/KBLELE,KBLSHP,KBLTYP
      COMMON/ZZZ31/NSTAG,NVORT,NSPIRAL,SPIRAL
      COMMON/ZZZ32/CSTAG,CVORT
      COMMON/ZZZ34/YCUT
      COMMON/ZZZ33/UWAKE
      COMMON/ZZZ50/XCTR,YCTR,ZCTR,RX,RY,RZ
      COMMON/ZZZ51/HSPAN,XLEZH,XTEZH,TANLEH,TANTEH,TAUH,ZP
      COMMON/ZZZ35/IIMIST,RPITCH,IMIST
      DIMENSION ACHORD(20),WNPP(2),WNPM(2),WNMP(2),WNMM(2)
      DIMENSION GG(20),KSFACE(20)
      DIMENSION TCHORD(10),TAXIS(10),VCHORD(10),VAXIS(10)
      REAL LSHAFT,LSHANK
C
      NSEX= 0
      DO 19 I=1,3
      READ(NREAD,10)  GG
19    WRITE(NWRITE,20)GG
      READ(NREAD,10)  GG(1),GG(2),KREAD
      WRITE(NWRITE,20)GG(1),GG(2),KREAD
10    FORMAT(20A4)
20    FORMAT(1X,20A4)
```

```
C
C     USE KSYMMY=0
C     USE KSYMMZ=0
C
      READ(NREAD,18)  GG(1),GG(2),NS,KSYMMY,KSYMMZ
      WRITE(NWRITE,28)GG(1),GG(2),NS,KSYMMY,KSYMMZ
      READ(NREAD,18)  GG(1),GG(2),NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,
     1 NSHAFT,NHUB,NSHANK,NBLADE
      WRITE(NWRITE,28)GG(1),GG(2),NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,
     1 NSHAFT,NHUB,NSHANK,NBLADE
      READ(NREAD,18)  GG(1),GG(2),KPYL1,KPYL2
      WRITE(NWRITE,28)GG(1),GG(2),KPYL1,KPYL2
18    FORMAT(2A4,10I5)
28    FORMAT(1X,2A4,10I5)
      READ(NREAD,12)  GG(1),GG(2),UMACH,OMEGA,AREA
      WRITE(NWRITE,22)GG(1),GG(2),UMACH,OMEGA,AREA
      READ(NREAD,12) GG(1),GG(2),ALFA,ABETA
      WRITE(NWRITE,22)GG(1),GG(2),ALFA,ABETA
12    FORMAT(2A4,7F8.3)
22    FORMAT(1X,2A4,7F10.3)
      IF(NPYLON.EQ.1)
     1READ(NREAD,12)  GG(1),GG(2),XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      IF(NPYLON.EQ.1)
     1WRITE(NWRITE,22)GG(1),GG(2),XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      IF(NVTAIL.EQ.1)
     1 READ(NREAD,12)  GG(1),GG(2),VSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAUV
     2 ,ZPV
      IF(NVTAIL.EQ.1)
     1WRITE(NWRITE,22) GG(1),GG(2),VSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAUV
     2 ,ZPV
C
      NTBD=NBODY1+NBODY2+NBODY3
      NROTOR=NSHAFT+NHUB+NSHANK+NBLADE
C
      IF(NTBD.NE.0)
     1READ(NREAD,12)GG(1),GG(2),XNOSE,XBD1,XBD2,XTAIL
      IF(NTBD.NE.0)
     1WRITE(NWRITE,22)GG(1),GG(2),XNOSE,XBD1,XBD2,XTAIL
      IF(NTBD.NE.0)
     1READ(NREAD,12)  GG(1),GG(2),YNOSE,YBD1,YBD2,YTAIL
      IF(NTBD.NE.0)
     1WRITE(NWRITE,22)GG(1),GG(2),YNOSE,YBD1,YBD2,YTAIL
      IF(NTBD.NE.0)
     1READ(NREAD,12)  GG(1),GG(2),ZNOSE,ZBD1,ZBD2,ZTAIL
      IF(NTBD.NE.0)
     1WRITE(NWRITE,22)GG(1),GG(2),ZNOSE,ZBD1,ZBD2,ZTAIL
      IF(NTBD.NE.0)
     1READ(NREAD,12)  GG(1),GG(2),RYBD1,RZBD1,RYBD2,RZBD2
      IF(NTBD.NE.0)
     1WRITE(NWRITE,22)GG(1),GG(2),RYBD1,RZBD1,RYBD2,RZBD2
C
      IF(NSHAFT.EQ.1)READ(NREAD,12)  GG(1),GG(2),RSHAFT,LSHAFT
      IF(NSHAFT.EQ.1)WRITE(NWRITE,22)GG(1),GG(2),RSHAFT,LSHAFT
      IF(NHUB.EQ.1)
     1 READ(NREAD,12)GG(1),GG(2),XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
      IF(NHUB.EQ.1)
     1WRITE(NWRITE,22)GG(1),GG(2),XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
```

```
      IF(NSHANK.EQ.1)  READ(NREAD,12)GG(1),GG(2),RSHANK,LSHANK
      IF(NSHANK.EQ.1)WRITE(NWRITE,22)GG(1),GG(2),RSHANK,LSHANK
      IF(NBLADE.EQ.1) READ(NREAD,12) GG(1),GG(2),RROTOR,YCUT,XBLE,XBTE,
     1 TANBLE,TANBTE,TAUBL
      IF(NBLADE.EQ.1)WRITE(NWRITE,22)GG(1),GG(2),RROTOR,YCUT,XBLE,XBTE,
     1 TANBLE,TANBTE,TAUBL
      TANLEB=TANBLE
      TANTEB=TANBTE
      IF(NBLADE.EQ.1)  READ(NREAD,12)GG(1),GG(2),THET75,THET1C,THET1S,
     1 CONING,AZIMUTH
      IF(NBLADE.EQ.1)WRITE(NWRITE,22)GG(1),GG(2),THET75,THET1C,THET1S,
     1 CONING,AZIMUTH
      IF(NBLADE.EQ.1)  READ(NREAD,12)GG(1),GG(2),RPITCH,TWIST
      IF(NBLADE.EQ.1)WRITE(NWRITE,22)GG(1),GG(2),RPITCH,TWIST
      IF(NBLADE.EQ.1)  READ(NREAD,18)GG(1),GG(2),KBLADE,ITWIST
      IF(NBLADE.EQ.1)WRITE(NWRITE,28)GG(1),GG(2),KBLADE,ITWIST
      READ(NREAD,13)  GG(1),GG(2),NWAKPY,NWAKHB,NWAKSK,NWAKBL
      WRITE(NWRITE,28)GG(1),GG(2),NWAKPY,NWAKHB,NWAKSK,NWAKBL
      IF((NWAKHB+NWAKSK+NWAKBL).NE.0)
     1 READ(NREAD,16)  GG(1),GG(2),NSPIRAL,SPIRAL,UWAKE
      IF((NWAKHB+NWAKSK+NWAKBL).NE.0)
     1 WRITE(NWRITE,26)GG(1),GG(2),NSPIRAL,SPIRAL,UWAKE
      IF(NWAKPY.EQ.1)  READ(NREAD,18)GG(1),GG(2),NSTAG,NVORT
      IF(NWAKPY.EQ.1)WRITE(NWRITE,28)GG(1),GG(2),NSTAG,NVORT
      IF(NWAKPY.EQ.1)  READ(NREAD,12)GG(1),GG(2),CSTAG,CVORT
      IF(NWAKPY.EQ.1)WRITE(NWRITE,22)GG(1),GG(2),CSTAG,CVORT
   16 FORMAT(   2A4,I5,2F8.3)
   26 FORMAT(1X,2A4,I5,2F8.3)
      READ(NREAD,19)  GG(1),GG(2),(KPRINT(K),K=1,10)
      WRITE(NWRITE,29)GG(1),GG(2),(KPRINT(K),K=1,10)
C
      IF(UMACH.GE. 1.0) CALL DEBUG(100)
      MULTY=1
      IF(KSYMMY.EQ.0)MULTY=2
      MULT=1
      IF(KSYMMZ.EQ.0)MULT=2
      MS=0
      IF(NIBD.NE.0)MS=MS+(NBODY1+NBODY2+NBODY3)*MULT*MULTY
      IF(NPYLON.NE.0.OR.NVTAIL.NE.0)MS=MS+(NPYLON+NVTAIL)*MULTY
      IF(NHUB.NE.0) MS=MS+NSHEET*MULTY+NHUB*MULT*MULTY
      IF (NROTOR.NE.0) MS=MS+KBLADE*(NSHANK+NBLADE*MULT)
C     IF(MS.NE.MS) CALL DEBUG(200)
C
C
      REFLEN=1.
      BETA=SQRT(ABS(UMACH**2-1.))
      KS=0
      NSBODY=0
      NSBTOT=0
C
C
C ---------------- NOSE -----------------------------------
C
      IF(NBODY1.EQ.0)GO TO 192
      KS=KS+1
      NSBODY=NSBODY+1
      READ(NREAD,18)  GG(1),GG(2),NX(KS),NY(KS),KNSELE,KNSSHP,KNSTYP
```

```
      WRITE(NWRITE,28)GG(1),GG(2),NX(KS),NY(KS),KNSELE,KNSSHP,KNSTYP
      NXY(KS)=NX(KS)*NY(KS)
      ISFACE(KS)=1
      KNORML(KS)=1
      KWAKES(KS)=0
      KROTORS(KS)=0
C
      IF(KSYMMY.NE.0)GO TO 170
      NSBODY=NSBODY+1
      JS=KS+(NBODY1+NBODY2+NBODY3)*MULT+NPYLON+NVTAIL
      NX(JS)=NX(KS)
      NY(JS)=NY(KS)
      NXY(JS)=NXY(KS)
      ISFACE(JS)=9
      KWAKES(JS)=0
      KNORML(JS)=-1
      KROTORS(JS)=0
170   CONTINUE
      IF(KSYMMZ.NE.0)GO TO 199
      NSBODY=NSBODY+1
      KSL=KS+NBODY1+NBODY2+NBODY3+NPYLON
      NX(KSL)=NX(KS)
      NY(KSL)=NY(KS)
      NXY(KSL)=NXY(KS)
      ISFACE(KSL)=5
      KWAKES(KSL)=0
      KNORML(KSL)=-1
      KROTORS(KSL)=0
C
      IF(KSYMMY.NE.0)GO TO 199
      NSBODY=NSBODY+1
      JSL=KSL+(NBODY1+NBODY2+NBODY3)*MULT+NPYLON+NVTAIL
      NX(JSL)=NX(KS)
      NY(JSL)=NY(KS)
      NXY(JSL)=NXY(KS)
      ISFACE(JSL)=13
      KWAKES(JSL)=0
      KNORML(JSL)=1
      KROTORS(JSL)=0
199   CONTINUE
C
C     -------------- FUSLAGE ------------------------------
C
      IF(NBODY2.EQ.0)GO TO 299
      KS=KS+1
      NSBODY=NSBODY+1
      READ(NREAD,18)  GG(1),GG(2),NX(KS),NY(KS),KBDELE,KBDSHP,KBDTYP
      WRITE(NWRITE,28)GG(1),GG(2),NX(KS),NY(KS),KBDELE,KBDSHP,KBDTYP
      NXY(KS)=NX(KS)*NY(KS)
      ISFACE(KS)=2
      KNORML(KS)=1
      KROTORS(KS)=0
      KWAKES(KS)=0
C
      IF(KSYMMY.NE.0)GO TO 270
      NSBODY=NSBODY+1
      JS=KS+(NBODY1+NBODY2+NBODY3)*MULT+NPYLON+NVTAIL
```

```
      NX(JS)=NX(KS)
      NY(JS)=NY(KS)
      NXY(JS)=NXY(KS)
      ISFACE(JS)=10
      KWAKES(JS)=0
      KNORML(JS)=-1
      KROTORS(JS)=0
  270 CONTINUE
      IF(KSYMMZ.NE.0)GO TO 299
      NSBODY=NSBODY+1
      KSL=KS+NBODY1+NBODY2+NBODY3+NPYLON
      NX(KSL)=NX(KS)
      NY(KSL)=NY(KS)
      NXY(KSL)=NXY(KS)
      ISFACE(KSL)=5
      KWAKES(KSL)=0
      KNORML(KSL)=-1
      KROTORS(KSL)=0
C
      IF(KSYMMY.NE.0)GO TO 299
      NSBODY=NSBODY+1
      JSL=KSL+(NBODY1+NBODY2+NBODY3)*MULT+NPYLON+NVTAIL
      NX(JSL)=NX(KS)
      NY(JSL)=NY(KS)
      NXY(JSL)=NXY(KS)
      ISFACE(JSL)=14
      KWAKES(JSL)=0
      KNORML(JSL)=-1
      KROTORS(JSL)=0
  299 CONTINUE
C
C  --------------- AFT-BODY ------------------------------
C
      IF(NBODY3.EQ.0)GO TO 399
      KS=KS+1
      NSBODY=NSBODY+1
      READ(NREAD,19)   GG(1),GG(2),NX(KS),NY(KS),KTNELE,KTNSHP,KTNTYP
      WRITE(NWRITE,20)GG(1),GG(2),NX(KS),NY(KS),KTNELE,KTNSHP,KTNTYP
      NXY(KS)=NX(KS)*NY(KS)
      ISFACE(KS)=3
      KNORML(KS)=1
      KWAKES(KS)=0
      KROTORS(KS)=0
C
      IF(KSYMMY.NE.0)GO TO 370
      NSBODY=NSBODY+1
      JS=KS+(NBODY1+NBODY2+NBODY3)*MULT+NPYLON+NVTAIL
      NX(JS)=NX(KS)
      NY(JS)=NY(KS)
      NXY(JS)=NXY(KS)
      ISFACE(JS)=11
      KWAKES(JS)=0
      KNORML(JS)=-1
      KROTORS(JS)=0
  370 CONTINUE
      IF(KSYMMZ.NE.0)GO TO 39-
      NSBODY=NSBODY+1
```

```
      KSL=KS+NBODY1+NBODY2+NBODY3+NPYLON
      NX(KSL)=NX(KS)
      NY(KSL)=NY(KS)
      NXY(KSL)=NXY(KS)
      ISFACE(KSL)=7
      KWAKES(KSL)=0
      KNORML(KSL)=-1
      KROTORS(KSL)=0
C
      IF(KSYMMY.NE.0)GO TO 399
      NSBODY=NSBODY+1
      JSL=KSL+(NBODY1+NBODY2+NBODY3)*MULT+NPYLON+NVTAIL
      NX(JSL)=NX(KS)
      NY(JSL)=NY(KS)
      NXY(JSL)=NXY(KS)
      ISFACE(JSL)=15
      KWAKES(JSL)=0
      KNORML(JSL)= 1
      KROTORS(JSL)=0
  399 CONTINUE
C
C  --------------- PYLON ----------------------------------
C
      IF(NPYLON.EQ.0)GO TO 499
      KS=KS+1
      NSBODY=NSBODY+1
      READ(NREAD,10)  GG(1),GG(2),NX(KS),NY(KS),KPYELE,KPYSHP,KPYTYP
      WRITE(NWRITE,20)GG(1),GG(2),NX(KS),NY(KS),KPYELE,KPYSHP,KPYTYP
      NXY(KS)=NX(KS)*NY(KS)
      ISFACE(KS)=4
      KNORML(KS)=1
      KWAKES(KS)=1
      KROTORS(KS)=0
C
      IF(KSYMMY.NE.0)GO TO 499
      NSBODY=NSBODY+1
      JS=KS+(NBODY1+NBODY2+NBODY3)*MULT+NPYLON+NVTAIL
      NX(JS)=NX(KS)
      NY(JS)=NY(KS)
      NXY(JS)=NXY(KS)
      ISFACE(JS)=12
      KWAKES(JS)=1
      KNORML(JS)=-1
      KROTORS(JS)=0
  499 CONTINUE
C
      NBODYS=NBODY1+NBODY2+NBODY3
C
C  --------------- VERTICAL TAIL --------------------------
C
      NSBODY=NSBODY+1
      IF(NVTAIL.EQ.0)GO TO 599
      KS=NBODYS*MULT+NPYLON+1
      READ(NREAD,10)  GG(1),GG(2),NX(KS),NY(KS),KVTELE,KVTSHP,KVTTYP
      WRITE(NWRITE,20)GG(1),GG(2),NX(KS),NY(KS),KVTELE,KVTSHP,KVTTYP
      NXY(KS)=NX(KS)*NY(KS)
       ISFACE(KS)=8
```

```
      KNORML(KS)=-1
      KWAKES(KS)=1
      KROTORS(KS)=0
C
      IF(KSYMMY.NE.0)GO TO 599
      NSBODY=NSBODY+1
      JS=KS+(NBODY1+NBODY2+NBODY3)*MULT+NPYLON+NVTAIL
      NX(JS)=NX(KS)
      NY(JS)=NY(KS)
      NXY(JS)=NXY(KS)
      ISFACE(JS)=16
      KWAKES(JS)=1
      KNORML(JS)=+1
      KROTORS(JS)=0
C
599   CONTINUE
C
C ------------- ROTOR SHAFT --------------
C
      IF(NSHAFT.EQ.0)GO TO 699
      NSBODY=NSBODY+1
      KS=(NBODY1+NBODY2+NBODY3)*MULT*MULTY+(NPYLON+NVTAIL)*MULTY
      KS=KS+1
      READ(NREAD,13)  GG(1),GG(2),NX(KS),NY(KS),KSHELE,KSHSHP,KSHTYP
      WRITE(NWRITE,28)GG(1),GG(2),NX(KS),NY(KS),KSHELE,KSHSHP,KSHTYP
      NXY(KS) = NX(KS)*NY(KS)
      ISFACE(KS) = 17
      KNORML(KS)=1
      KWAKES(KS)=0
      KROTORS(KS)=1
C
      IF(KSYMMY.NE.0)GO TO 699
      NSBODY=NSBODY+1
      JS=KS+1
      NX(JS)=NX(KS)
      NY(JS)=NY(KS)
      NXY(JS)=NXY(KS)
      ISFACE(JS)=18
      KWAKES(JS)=0
      KNORML(JS)=-1
      KROTORS(JS)=1
C
699   CONTINUE
C
C --------------- ROTOR HUB --------------
C
      IF(NHUB.EQ.0)GO TO 799
      KS=NBODYS*MULT*MULTY+(NPYLON+NVTAIL+NSHAFT)*MULTY
      KS=KS+1
      NSBODY=NSBODY+1
      READ(NREAD,13) GG(1),GG(2),NX(KS),NY(KS),KHBELE,KHBSHP,KHBTYP
      WRITE(NWRITE,28)GG(1),GG(2),NX(KS),NY(KS),KHBELE,KHBSHP,KHBTYP
      NXY(KS)=NX(KS)*NY(KS)
      ISFACE(KS)=13
      KNORML(KS)=1
      KWAKES(KS)=1
      KROTORS(KS)=1
```

```
C
      IF(KSYMMY.NE.0)GO TO 770
      NSBODY=NSBODY+1
      JS=KS+NHUB*MULT
      NX(JS)=NX(KS)
      NY(JS)=NY(KS)
      NXY(JS)=NXY(KS)
      ISFACE(JS)=21
      KWAKES(JS)=1
      KNORML(JS)=-1
      KROTORS(JS)=1
  770 CONTINUE
      IF(KSYMMZ.NE.0)GO TO 799
      NSBODY=NSBODY+1
      KSL=KS+1
      NX(KSL)=NX(KS)
      NY(KSL)=NY(KS)
      NXY(KSL)=NXY(KS)
      ISFACE(KSL)=20
      KWAKES(KSL)=1
      KNORML(KSL)=-1
      KROTORS(KSL)=1
C
      IF(KSYMMY.NE.0)GO TO 799
      NSBODY=NSBODY+1
      JSL=JS+NHUB*MULT
      JSL=KSL+NHUB*MULT
      NX(JSL)=NX(KS)
      NY(JSL)=NY(KS)
      NXY(JSL)=NXY(KS)
      ISFACE(JSL)=22
      KWAKES(JSL)=1
      KNORML(JSL)=1
      KROTORS(JSL)=1
  799 CONTINUE
C
C   --------------- ROTOR BLADE SHANK ---------------
C
      IF(NSHANK.EQ.0)GO TO 899
      KS=(NBODY1+NBODY2+NBODY3)*MULT*MULTY+(NPYLON+NVTAIL)*MULTY+
     1NSHAFT*MULTY+NHUB*MULT*MULTY+1
      READ(NREAD,10)  GG(1),GG(2),NX(KS),NY(KS),KSKELE,KSKSHP,KSKTYP
      WRITE(NWRITE,20)GG(1),GG(2),NX(KS),NY(KS),KSKELE,KSKSHP,KSKTYP
C
      DO 810 K=1,KBLADE
      NSBODY=NSBODY+1
      KSS=KS+(K-1)*(NSHANK+NBLADE*MULT)
      NX(KSS)=NX(KS)
      NY(KSS)=NY(KS)
      NXY(KSS)=NX(KS)*NY(KS)
      ISFACE(KSS)=23+(K-1)*3
      KNORML(KSS)=1
      KWAKES(KSS)=1
      KROTORS(KSS)=1
  810 CONTINUE
C
  899 CONTINUE
```

```
C
C  --------------- ROTOR BLADE ---------------
C
      IF(NBLADE.EQ.0)GO TO 999
      KS=   (NBODY1+NBODY2+NBODY3)*MULT*MULTY+(NPYLON+NVTAIL)*MULTY+
     1 NSHAFT*MULTY+NHUB*MULT*MULTY+NSHANK+1
      READ(NREAD,10)   GG(1),GG(2),NX(KS),NY(KS),KBLELE,KBLSHP,KBLTYP
      WRITE(NWRITE,20)GG(1),GG(2),NX(KS),NY(KS),KBLELE,KBLSHP,KBLTYP
C
      DO 910 K=1,KBLADE
      NSBODY=NSBODY+1
      KSS=KS+(K-1)*(NSHANK+NBLADE*MULT)
      NX(KSS)=NX(KS)
      NY(KSS)=NY(KS)
      NXY(KSS)=NX(KS)*NY(KS)
      ISFACE(KSS)=24+(K-1)*3
      KNORML(KSS)=1
      KWAKES(KSS)=1
      KROTORS(KSS)=1
C
      IF(KSYMMZ.NE.0)GO TO 910
      NSBODY=NSBODY+1
      KSSL=KSS+1
      NX(KSSL)=NX(KSS)
      NY(KSSL)=NY(KSS)
      NXY(KSSL)=NXY(KSS)
      ISFACE(KSSL)=25+(K-1)*3
      KWAKES(KSSL)=1
      KNORML(KSSL)=-1
      KROTORS(KSSL)=1
910   CONTINUE
C
999   CONTINUE
C
C
      NELEM=0
      WRITE(6,8002)
      DO 1000 IS=1,NS
1000  NELEM=NELEM+NXY(IS)
      WRITE(6,8001)NELEM
 8001 FORMAT(//5X,*NELEM = *,I5/)
C
8002  FORMAT(/10X,4HDATA)
C
      NSBTOT=0
      DO 1100 IS=1,NS
      NT(IS)=NSBTOT
      NSBTOT=NSBTOT+NX(IS)*NY(IS)
      WRITE(6,8003)IS,NX(IS),NY(IS),NXY(IS),ISFACE(IS),NT(IS),
     1KNORML(IS),KWAKES(IS)
8003  FORMAT (5X,*IS= *,I5,2X,*NX=*,I5,2X,*NY=*,I5,
     1   *  NXY=*,I5,*  ISFACE=*,I5,*  NT=*,I5,
     2   *  KNORML=*,I5,*  KWAKES=*,I5)
1100  CONTINUE
C
C
      RETURN
      END
```

```
C
      SUBROUTINE COORPT(NELEM,NXYMP,NOECT,XK,NNODE)
C
      COMMON/ZZZ1/NX(34),NY(34),NXY(34),KSYMMY,KSYMMZ,NSYMMY,NSYMMZ
      COMMON/ZZZ2/NSFX,NSBODY,NS,NT(34),ISFACE(34),KNORML(34),KWAKES(34)
      COMMON/ZZZ3/NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,NSHAFT,NHUB,NSHANK,
     1 NBLADE
      COMMON/ZZZ4/UMACH,OMEGA,ALFA,ABETA
      COMMON/ZZZ5/XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      COMMON/ZZZ6/XNOSE,XBD1,XBD2,XTAIL
      COMMON/ZZZ7/YNOSE,YBD1,YBD2,YTAIL
      COMMON/ZZZ8/ZNOSE,ZBD1,ZBD2,ZTAIL
      COMMON/ZZZ9/RYBD1,RZBD1,RYBD2,RZBD2
      COMMON/ZZZ10/RSHAFT,LSHAFT,RSHANK,LSHANK
      COMMON/ZZZ11/XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
      COMMON/ZZZ12/RROTOR,BCHORD,TAUBL,ALFAB
      COMMON/ZZZ13/THET75,THET1C,THET1S,CONING,AZIMUTH
      COMMON/ZZZ14/KBLADE,TANLEB,TANTEB,XBLE,XBTE,KROTORS(34)
      COMMON/ZZZ15/VSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAUV,ZVTAIL
      COMMON/ZZZ16/NWAKPY,NWAKHB,NWAKSK,NWAKBL
      COMMON/ZZZ17/WAKLPY,WAKLHB,WAKLSK,WAKLBL
      COMMON/ZZZ18/WANGPY,WANGHB,WANGSK,WANGBL
      COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
      COMMON/ZZZ20/PI
      COMMON/ZZZ21/KPY1,KPY2
      COMMON/ZZZ22/KNSELE,KNSSHP,KNSTYP
      COMMON/ZZZ23/KBDELE,KBDSHP,KBDTYP
      COMMON/ZZZ24/KTNELE,KTNSHP,KTNTYP
      COMMON/ZZZ25/KPYELE,KPYSHP,KPYTYP
      COMMON/ZZZ26/KVTELE,KVTSHP,KVTTYP
      COMMON/ZZZ27/KSHELE,KSHSHP,KSHTYP
      COMMON/ZZZ28/KHBELE,KHBSHP,KHBTYP
      COMMON/ZZZ29/KSKELE,KSKSHP,KSKTYP
      COMMON/ZZZ30/KBLELE,KBLSHP,KBLTYP
      COMMON/ZZZ31/NSTAG,NVORT,NSPIRAL,SPIRAL
      COMMON/ZZZ33/UWAKE
      COMMON/ZZZ34/YCUT
      COMMON/ZZZ50/XCTR,YCTR,ZCTR,RX,RY,RZ
      COMMON/ZZZ51/HSPAN,XLEZH,XTEZH,TANLEH,TANTEH,TAUH,ZP
      COMMON/ZZZ35/ITWIST,RPITCH,TWIST
      DIMENSION ACHORD(20),WNPP(2),WNPM(2),WNMP(2),WNMM(2)
      DIMENSION XK(3,NNODE),NOECT(NXYMP,34),GG(20),KSFACE(34)
      DIMENSION DFPP(2),DFPM(2),DFMP(2),DFMM(2)
      DIMENSION HCHORD(11),HAXIS(11),VCHORD(11),VAXIS(11)
      DIMENSION HCSI(11),HETA(11)
      REAL LSHAFT,LSHANK
C
      NSFX=34
      KREAD=0
C
      IF(KREAD.EQ.0)GO TO 9
      READ(NREAD,15)  ((XK(K,INODE),K=1,3),INODE=1,NNODE)
      WRITE(NWRITE,25)((XK(K,INODE),K=1,3),INODE=1,NNODE)
8     FORMAT(3E12.4)
      GO TO 900
9     CONTINUE
C
```

```
      REFLEN=1.
      BETA=SQRT(ABS(UMACH**2-1.))
      MULT=1
      IF(KSYMMZ.EQ.0)MULT=2
      MULTY=1
      IF(KSYMMY.EQ.0)MULTY=2
   15 FORMAT(10F8.3)
   25 FORMAT(1X,10F8.3)
      PI=3.14159265
  388 FORMAT(2X,*IS=*,I5,2X,*IX=*,I5,2X,*IY=*,I5,2X,*IXY=*,I5,2X,
     1 *NOFCT=*,I5)
C
C
      KFACE=NBODY1+NBODY2+NBODY3+NPYLON
C
C     ========== PYLON ==========
C
      IF(NPYLON.EQ.0)GO TO 19.
      KS=KFACE
      DXX=1./NX(KS)
      DYY=1./NY(KS)
      NXP=NX(KS)+1
      NYP=NY(KS)+1
      LPYELE=KPYELE
      IF(LPYELE.NE.0) GO TO 1:2
      IF(LPYELE.NE.0) GO TO 102
      LPYELE=1
      READ(NREAD,15)    (HCSI(IX),IX=1,NXP)
      WRITE(NWRITE,25)  (HCSI(IX),IX=1,NXP)
      READ(NREAD,15)    (HETA(IY),IY=1,NYP)
      WRITE(NWRITE,25)  (HETA(IY),IY=1,NYP)
  102 CONTINUE
      DO 118 IX=1,NXP
      DO 118 IY=1,NYP
      XX=(IX-1)*DXX
      YY=(IY-1)*DYY
      IF(KPYELE.EQ.0) XX=HCSI(IX)
      IF(KPYELE.EQ.0) YY=HETA(IY)
      GO  TO(131,132,133),LPY:LE
131   CONTINUE
      CSI=XX
      ETA=YY
      GO TO 113
132   CONTINUE
      CSI=XX*XX
      ETA=YY
133   CONTINUE
      CSI=1.-(1.-XX)**2
      ETA=YY
113   CONTINUE
      THETA=PI*ETA
      RX=CSI*RXPYL
      RY=CSI*RYPYL
      X8=RX*COS(THETA)
      Y8=RY*SIN(THETA)
      Z8=RZPYL*SQRT(1.-(X8/RXPYL)**2-(Y8/RYPYL)**2)
      IXY=IX+(IY-1)*NXP
```

```
      INODE=NOFCT(IXY,KS)
      XK(1,INODE)=X0+XPYCTR
      XK(2,INODE)=Y0+YPYCTR
      XK(3,INODE)=Z0+ZPYCTR
      WRITE(6,140)IX,IY,IXY,CSI,ETA,INODE
      WRITE(6,141)THETA,RX,RY
      WRITE(6,142)X0,Y0,Z0
      WRITE(6,143)(XK(L,INODE),L=1,3)
  140 FORMAT(10X,*IX=*,I5,2X,*IY=*,I5,2X,*IXY=*,I5,2X,*CSI=*,E12.6,2X,
     1*ETA=*,E12.6,2X,*INODE=*,I5)
  141 FORMAT(10X,*THETA=*,E12.6,2X,*RX=*,E12.6,2X,*RY=*,E12.6)
  142 FORMAT(10X,*X0=*,E12.6,2X,*Y0=*,E12.6,2X,*Z0=*,E12.6)
  143 FORMAT(10X,*XK=*,3(E12.6,2X))
 119  CONTINUE
 199  CONTINUE
C
C
      KS=0
C
C     ===========NOSE==============================
C
      IF(NBODY1.EQ.0)GO TO 599
      KS=KS+1
      DO 598 IBODY1=1,MULI
      IF(IBODY1.EQ.1) SIGNZ=+1.
      IF(IBODY1.EQ.2)SIGNZ=-1.
      NXP=NX(KS)+1
      NYP=NY(KS)+1
      DXX=1./NX(KS)
      TINCR=0.5*PI/NY(KS)
      DO 550 IX=1,NXP
      XX=(IX-1)*DXX
      IF(KNSELE.EQ.1)CSI=XX
      IF(KNSELE.EQ.2)CSI=XX*XX
      X=XNOSE+(XBD1-XNOSE)*CSI
      IF(KNSSHP.EQ.1)RRY=RYBD1*SQRT(CSI)
      IF(KNSSHP.EQ.1) RRZ=RZBD1*SQRT(CSI)
      IF(KNSSHP.EQ.2)RRY=RYBD1*(CSI)**.3333333
      IF(KNSSHP.EQ.2) RRZ=RZBD1*(CSI)**.3333333
      IF(KNSSHP.EQ.3)RRY=RYBD1*(CSI)**.25
      IF(KNSSHP.EQ.3)RRZ=RZBD1*(CSI)**.25
      DO 550 IY=1,NYP
      THET=(IY-1)*TINCR
      THETA=(+0.5*PI-THET)
      ETA=COS(THETA)
      YY=RRY*ETA
      ZZ=SIGNZ*RRZ*SIN(THETA)
      DELZ=(ZBD1-ZNOSE)
      DOWNZ=DELZ-DELZ*CSI
      ZZ=ZZ-DOWNZ
      ZZ=ZZ+ZBD1
C
C
      IXY=IX+(IY-1)*NXP
      IF(IBODY1.EQ.1) IS=KS
      IF(IBODY1.EQ.2) IS=KS+KFACE
      WRITE(6,140)IX,IY,IXY,CSI,ETA,NOFCT(IXY,IS)
```

```
      WRITE(6,142)X,YY,ZZ
      XK(1,NOFCT(IXY,IS))=X
      XK(2,NOFCT(IXY,IS))=YY
      XK(3,NOFCT(IXY,IS))=ZZ
550   CONTINUE
598   CONTINUE
599   CONTINUE
C
C     -----------BODY---------------------------
C
      IF(NBODY2.EQ.0)GO TO 69
      KS=KS+1
      DO 698 IBODY2=1,MULT
      IF(IBODY2.EQ.1)SIGNZ=+1.
      IF(IBODY2.EQ.2)SIGNZ=-1.
      NXP=NX(KS)+1
      NYP=NY(KS)+1
      TINCR=0.5*PI/NY(KS)
      DXX=1./NX(KS)
      DO 631 IX=1,NXP
      XXX=(IX-1)*DXX
      IF(KBDELE.EQ.1)CSI=XXX
      IF(KBDELE.EQ.2)CSI=XXX*XXX
      R1=RYBD1+(RYBD2-RYBD1)*CSI
      R2=RZBD1+(RZBD2-RZBD1)*CSI
      DELZ=ZBD2-ZBD1
      ZZZ=DELZ*CSI
      XX=XBD1+(XBD2-XBD1)*CSI
      DO 631 IY=1,NYP
      THETA=(0.5*PI     -(IY-1)*TINCR)
      YY=R1*COS(THETA)
      ZZ=SIGNZ*R2*SIN(THETA)
      ZZ=ZZ+ZZZ+ZBD1
      IXY=IX+(IY-1)*NXP
      IF(IBODY2.EQ.1)IS=KS
      IF(IBODY2.EQ.2)IS=KS+KFACE
      XK(1,NOFCT(IXY,IS))=XX
      XK(2,NOFCT(IXY,IS))=YY
      XK(3,NOFCT(IXY,IS))=ZZ
631   CONTINUE
698   CONTINUE
699   CONTINUE
C
C
C     -----------TAIL NOSE-----------------------
C
      IF(NBODY3.EQ.0)GO TO 899
      KS=KS+1
      DO 898 IBODY3=1,MULT
      IF(IBODY3.EQ.1)SIGNZ=+1.
      IF(IBODY3.EQ.2)SIGNZ=-1
      NXP=NX(KS)+1
      NYP=NY(KS)+1
      DXX=1./NX(KS)
      TINCR=0.5*PI/NY(KS)
      DO 858 IX=1,NXP
      XX=(IX-1)*DXX
```

```
      XX=1.-XX
      IF(KTNELE.EQ.1)CSI=XX
      IF(KTNELE.EQ.2)CSI=XX*XX
      IF(KTNSHP.EQ.1)RRY=RYBD2*SQRT(CSI)
      IF(KTNSHP.EQ.1)RRZ=RZBD2*SQRT(CSI)
      IF(KTNSHP.EQ.2)RRY=RYBD2*CSI
      IF(KTNSHP.EQ.2)RRZ=RZBD1*CSI
      CSI=1.-CSI
      X=XBD2+(XTAIL-XBD2)*CSI
      DO 850 IY=1,NYP
      THET=(IY-1)*TINCR
      THETA=(+0.5*PI-THET)
      ETA=COS(THETA)
      YY=RRY*ETA
      ZZ=SIGNZ*RRZ*SIN(THETA)
C
C
      DELZ=ZTAIL-ZBD2
      DOWNZ=CELZ*CSI
      ZZ=ZZ+DOWNZ+ZBD2
C
C
      IXY=IX+(IY-1)*NXP
      IF(IBODY3.EQ.1)IS=KS
      IF(IBODY3.EQ.2)IS=KS+KFACE
      XK(1,NOFCT(IXY,IS))=X
      XK(2,NOFCT(IXY,IS))=YY
      XK(3,NOFCT(IXY,IS))=ZZ
850   CONTINUE
898   CONTINUE
899   CONTINUE
C
C     ---------- VERTICAL TAIL -----------
C
      IF(NVTAIL.EQ.0)GO TO 399
      KS=(NBODY1+NBODY2+NBODY3)*MULT+NPYLON+1
      DO 398 IVTL=1,1
C
      IF(KVTTYP.EQ.1)GO TO 3170
      READ(NREAD,15)   GG(1),GG(2),WNPP,WNPM,WNMP,WNMM
      WRITE(NWRITE,25)GG(1),GG(2),WNPP,WNPM,WNMP,WNMM
3170  CONTINUE
      SIGNZ=+1.
      TAILLN=VSPAN-2.*R
      TAILWD=TAILLN/2.
      RLE=0.
      RTE=0.
      DXX=1./NX(KS)
      DYY=1./NY(KS)
      NXP=NX(KS)+1
      NYP=NY(KS)+1
      LVTELE=KVTELE
      IF(LVTELE.NE.0)GO TO 3130
      LVTELE=1
      READ(NREAD,15)   GG(1),GG(2),(HCSI(IX),IX=1,NXP)
      WRITE(NWRITE,25)GG(1),GG(2),(HCSI(IX),IX=1,NXP)
      READ(NREAD,15)   GG(1),GG(2),(HETA(IY),IY=1,NYP)
```

```
      WRITE(NWRITE,25)GG(1),GG(2),(HETA(IY),IY=1,NYP)
3100  CONTINUE
      DO 318 IX=1,NXP
      DO 318 IY=1,NYP
      XX=(IX-1)*DXX
      YY=(IY-1)*DYY
      IF(KVTELE.EQ.0)XX=HCSI(IX)
      IF(KVTELE.EQ.0)YY=HETA(IY)
      GO TO(3131,3132,3133,3134),LVTELE
3131  CONTINUE
      CSI=XX
      ETA=YY
      GO TO 313
3132  CONTINUE
      CSI=XX*XX
      ETA=1.-(1.-YY)**2
      GO TO 313
3133  CONTINUE
      CSI=XX
      ETA=1.-(1.-YY)**2
      GO TO 313
3134  CONTINUE
      CSI=XX*XX
      ETA=YY
313   CONTINUE
C     IF(KVTTYP.NE.1)GO TO 3139
      Y=TAILWD*ETA
      XLE=XLEZV+TANLEV*(Y-RLE)
      XTE=XTEZV+TANTEV*(Y-RTE)
      VCHORD(IY)=XTE-XLE
      VAXIS(IY)=XLE+VCHORD(IY)*0.5
      X=XLE+(XTE-XLE)*CSI
C
3139  CONTINUE
      IF(KVTTYP.NE.2)GO TO 31 9
      X1=(WNPP(1)-WNMP(1))*CSI+WNMP(1)
      Y1=(WNPP(2)-WNMP(2))*CS.+WNMP(2)
      X2=(WNPM(1)-WNMM(1))*CSI+WNMM(1)
      Y2=(WNPM(2)-WNMM(2))*CSI+WNMM(2)
      X3=(WNPP(1)-WNPM(1))*ETA+WNPM(1)
      Y3=(WNPP(2)-WNPM(2))*ET +WNPM(2)
      X4=(WNMP(1)-WNMM(1))*ETA+WNMM(1)
      Y4=(WNMP(2)-WNMM(2))*ETA+WNMM(2)
      DET=(X1-X2)*(Y3-Y4)-(X3-X4)*(Y1-Y2)
      IF(DET.EQ.0.)GO TO 3147
      X=((X1-X2)*(X4*Y3-X3*Y4)-(X3-X4)*(X2*Y1-X1*Y2))/DET
      Y=((Y1-Y2)*(X4*Y3-X3*Y4)-(Y3-Y4)*(X2*Y1-X1*Y2))/DET
      GO TO 3149
3147  CONTINUE
      X=X4
      Y=Y4
3149  CONTINUE
C
      GO TO (3151,3152,3153),KISHA
3151  CONTINUE
C
C     FOR CIRCULAR BICONVEX
```

```
C
      XC=0.5*(XLE+XTE)
      PL=0.5*(XTE-XLE)
      H=TAUV*PL
      ATAU=2.*H
      ETACR=1.-ATAU/VSPAN
      XXC=X-XC
      Z=0.
      IF(H.EQ.0..OR.IY.EQ.NYP.OR.IX.EQ.1.OR.IX.EQ.NXP)GO TO 315
      Z=SIGNZ*(SQRT(((PL*PL+H*H)/(2.*H))**2-XXC**2)-(PL*PL-H*H)/(2.*H))
      IF(ETA.GE.ETACR)Z=Z*SQRT(1.-((ETA-ETACR)*VSPAN/ATAU)**2)
      GO TO 315
3152  CONTINUE
      TAUBAR=TAUV*.75*SQRT(3.)*(XTEZV-XLEZV)
      Z=SIGNZ*TAUBAR*SQRT(CSI)*(1.-CSI)*SQRT(1.-ETA**2)
      GO TO 315
3153  CONTINUE
      Z=SIGNZ*4.*TAUV*(XTEZV-XLEZV)*CSI*(1.-CSI)*SQRT(1.-ETA**2)
315   CONTINUE
C
      IXY=IX+(IY-1)*NXP
      XK(1,NOFCT(IXY,KS))=X
      XK(2,NOFCT(IXY,KS))=Z
      XK(3,NOFCT(IXY,KS))=Y+ZVTAIL
318   CONTINUE
398   CONTINUE
399   CONTINUE
C
C     ----------  SHAFT --------
C
      IF(NSHAFT.EQ.0)GO TO 299
      KS=(NBODY1+NBODY2+NBODY3)*MULT*MULTY+(NPYLON+NVTAIL)*MULTY
      KS=KS+1
      DXX=1./NX(KS)
      DYY=1./NY(KS)
      NXP=NX(KS)+1
      NYP=NY(KS)+1
      LSHELE=KSHELE
      IF(LSHELE.NE.0) GO TO 201
      IF(LSHELE.NE.0)GO TO 201
      LSHELE=1
      READ(NREAD,15)  (HCSI(IX),IX=1,NXP)
      WRITE(NWRITE,25)(HCSI(IX),IX=1,NXP)
      READ(NREAD,15)  (HETA(IY),IY=1,NYP)
      WRITE(NWRITE,25)(HETA(IY),IY=1,NYP)
  201 CONTINUE
      DO 218 IX=1,NXP
      DO 218 IY=1,NYP
      XX=(IX-1)*DXX
      YY=(IY-1)*DYY
      IF(KSHELE.EQ.0) XX=HCSI(IX)
      IF(KSHELE.EQ.0) YY=HETA(IY)
      GO TO (231,232,233),LSHELE
  231 CONTINUE
      CSI=XX
      ETA=YY
      GO TO 213
```

```
232   CONTINUE
      CSI=XX*XX
      ETA=YY
      GO TO 213
233   CONTINUE
      CSI=1.-(1.-XX)**2
      ETA=YY
213   CONTINUE
      THETA=PI*ETA
      R=RSHAFT
      X0=R*COS(THETA)
      Y0=R*SIN(THETA)
      Z0=CSI*LSHAFT
      IXY=IX+(IY-1)*NXP
      INODE=NOFCT(IXY,KS)
      XK(1,INODE)=X0+XPYCTR
      XK(2,INODE)=Y0+YPYCTR
      XK(3,INODE)=ZPYCTR+LSHAFT-Z0*RZPYL
      WRITE(6,61)KS,IX,IY,IXY,INODE
      WRITE(6,62)X0,Y0,Z0
      WRITE(6,63)(XK(L,INODE),L=1,3)
   61 FORMAT(10X,*KS=*,I5,*  IX=*,I5,*  IY=*,I5,*  IXY=*,I5,
     1 *  INODE=*,I5)
   62 FORMAT(10X,*X0=*,E12.6,*  Y0=*,E12.6,*  Z0=*,E12.6)
   63 FORMAT(10X,* XK= *,3(E12.6,2X))
218   CONTINUE
299   CONTINUE
C
      IF(NHUB.EQ.0) GO TO 499
      KS=(NBODY1+NBODY2+NBODY3)*MULT*MULTY+(NPYLON+NVTAIL)*MULTY+
     1 NSHAFT*MULTY
      KS=KS+1
      DO 498 IMULT=1,MULT
C
      IF(IMULT.EQ.1) SIGNZ= 1
      IF(IMULT.EQ.2) SIGNZ=-1.
C
      DXX=1./NX(KS)
      DYY=1./NY(KS)
      NXP=NX(KS)+1
      NYP=NY(KS)+1
      LHBELE=KHBELE
      IF(LHBELE.NE.0)GO TO 400
      LHBELE=1
      READ(NREAD,15)   (HCSI(IX),IX=1,NXP)
      WRITE(NWRITE,25)(HCSI(IX),IX=1,NXP)
      READ(NREAD,15)   (HETA(IY),IY=1,NYP)
      WRITE(NWRITE,25)(HETA(IY),IY=1,NYP)
400   CONTINUE
      DO 410 IX=1,NXP
      DO 410 IY=1,NYP
      XX=(IX-1)*DXX
      YY=(IY-1)*DYY
      IF(KHBELE.EQ.0) XX=HCSI(IX)
      IF(KHBELE.EQ.0) YY=HETA(IY)
      GO TO (431,432,433),LHBELE
431   CONTINUE
```

```
      CSI=XX
      ETA=YY
      GO TO 413
  432 CONTINUE
      CSI=XX*XX
      ETA=YY
      GO TO 413
  433 CONTINUE
      CSI=1.-(1.-XX)**2
      ETA=YY
  413 CONTINUE
      THETA=PI*ETA
      RX=CSI*RXHUB
      RY=CSI*RYHUB
      X0=RX*COS(THETA)
      Y0=RY*SIN(THETA)
      Z0=SIGNZ*RZHUB*SQRT(1.- X0/RXPYL)**2-(Y0/RYPYL)**2)
      IXY=IX+(IY-1)*NXP
      IS=KS+(IMULT-1)
      INODE=NOFCT(IXY,IS)
      XK(1,INODE)=X0+XHUBCR
      XK(2,INODE)=Y0+YHUBCR
      XK(3,INODE)=Z0+ZHUBCR
      WRITE(6,61)IS,IX,IY,IXY,INODE
      WRITE(6,62)X0,Y0,Z0
      WRITE(6,63)(XK(I,INODE),I=1,3)
  418 CONTINUE
  498 CONTINUE
  499 CONTINUE
C
C
  900 CONTINUE
C
      NSS=(NBODY1+NBODY2+NBODY3)*MULT+NPYLON
     1 +NVTAIL
      DO 910 IS=1,NSS
      JS=IS+NSS
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 910 IX=1,NXP
      DO 910 IY=1,NYP
      IXY=IX+(IY-1)*NXP
      XK(1,NOFCT(IXY,JS))=XK(1,NOFCT(IXY,IS))
      XK(2,NOFCT(IXY,JS))=-XK(2,NOFCT(IXY,IS))
      XK(3,NOFCT(IXY,JS))=XK(3,NOFCT(IXY,IS))
      WRITE(6,54)IXY,IS
   54 FORMAT(10X,*IXY=*,I5,2X,*IS=*,I5)
  910 CONTINUE
C
      IF(NSHAFT.EQ.0) GO TO 911
      IS=NSS*MULTY+1
      JS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 912 IX=1,NXP
      DO 912 IY=1,NYP
      IXY=IX+(IY-1)*NXP
```

```
      WRITE(6,54)IXY,IS
      XK(1,NOFCT(IXY,JS))= XK(1,NOFCT(IXY,IS))
      XK(2,NOFCT(IXY,JS))=-XK(2,NOFCT(IXY,IS))
      XK(3,NOFCT(IXY,JS))= XK(3,NOFCT(IXY,IS))
  912 CONTINUE
  911 CONTINUE
C
      IF(NHUB.EQ.0) GO TO 913
      IS1=NSS*MULTY+NSHAFT*MULTY+1
      IS2=IS1+1
      DO 914 IS=IS1,IS2
      JS=IS+MULTY
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 915 IX=1,NXP
      DO 915 IY=1,NYP
      IXY=IX+(IY-1)*NXP
      WRITE(6,54)IXY,IS
      XK(1,NOFCT(IXY,JS))= XK(1,NOFCT(IXY,IS))
      XK(2,NOFCT(IXY,JS))=-XK(2,NOFCT(IXY,IS))
      XK(3,NOFCT(IXY,JS))= XK(3,NOFCT(IXY,IS))
  915 CONTINUE
  914 CONTINUE
  913 CONTINUE
C
C
C
C     ========== BLADE  SHANK ==========
C
      IF(NSHANK.EQ.0)GO TO 799
      KS=(NBODY1+NBODY2+NBODY3)*MULT*MULTY+(NPYLON+NVTAIL)*MULTY+
     1 NHUB*MULT*MULTY+NSHAFT*MULTY+1
      DO 798 IB=1,KBLADE
C
      IF(IB.EQ.1)SIGNY=1.
      IF(IB.EQ.2)SIGNY=-1.
C
      DXX=1./NX(KS)
      DYY=1./NY(KS)
      NXP=NX(KS)+1
      NYP=NY(KS)+1
      LSKELE=KSKELE
      IF(LSKELE.NE.0)GO TO 700
      LSKELE=1
      READ(NREAD,15)  (HCSI(IX);IX=1,NXP)
      WRITE(NWRITE,25)(HCSI(IX),IX=1,NXP)
      READ(NREAD,13)  (HETA(IY),IY=1,NYP)
      WRITE(NWRITE,25)(HETA(IY),IY=1,NYP)
700   CONTINUE
      DO 718 IX=1,NXP
      DO 718 IY=1,NYP
      XX=(IX-1)*DXX
      YY=(IY-1)*DYY
      IF(KSKELE.EQ.0) XX=HCSI(IX)
      IF(KSKELE.EQ.0) YY=HETA(IX)
731   CONTINUE
      CSI=XX
```

```
      ETA=YY
      GO TO 713
732   CONTINUE
      CSI=1.-(1.-XX)**2
      ETA=YY
      GO TO 713
733   CONTINUE
      CSI=XX*XX
      ETA=YY
713   CONTINUE
      THETA=2.*PI*ETA
      R=RSHANK
      X0=R*COS(THETA)
      Z0=R*SIN(THETA)
      Y0=CSI*LSHANK
C
      IXY=IX+(IY-1)*NXP
      IS=KS+(IB-1)*(NBLADE*MULT+NSHANK)
      INODE=NOFCT(IXY,IS)
      XK(1,INODE)=XHUBCR+X0
      XK(2,INODE)=SIGNY*(YHUBCR+RYHUB+LSHANK-Y0)
      XK(3,INODE)=ZHUBCR+Z0
      WRITE(6,61)IS,IX,IY,IXY,INODE
      WRITE(6,62)X0,Y0,Z0
      WRITE(6,63)(XK(L,INODE),L=1,3)
718   CONTINUE
798   CONTINUE
799   CONTINUE
C
C
C
C
C     --------- ROTOR BLADE --------
C
      IF(NBLADE.EQ.0) GO TO 1099
      KKS=(NBODY1+NBODY2+NBODY3)*MULT*MULTY+(NPYLON+NVTAIL)*MULTY
     1 +NSHAFT*MULTY+NHUB*MULT*MULTY+NSHANK
      DO 1098 IB=1,KBLADE
      KS=KKS+1+(IB-1)*(NBLADE*MULT+NSHANK)
      DO 1097 IMULT=1,MULT
      WRITE(6,55)IB,IMULT,IXY,IS,X,Y,Z
C
      SIGNY=1.
      IF(IMULT.EQ.1)SIGNZ=1.
      IF(IMULT.EQ.2)SIGNZ=-1.
C
      DXX=1./NX(KS)
      DYY=1./NY(KS)
      NXP=NX(KS)+1
      NYP=NY(KS)+1
      LBLELE=KBLELE
      IF(LBLELE.NE.0)GO TO 1088
      LBLELE=1
      READ(NREAD,15)  (HCSI(IX),IX=1,NXP)
      WRITE(NWRITE,25)(HCSI(IX),IX=1,NXP)
      READ(NREAD,15)  (HETA(IY),IY=1,NYP)
      WRITE(NWRITE,25)(HETA(IY),IY=1,NYP)
```

```
 1000  CONTINUE
       DO 1018 IX=1,NXP
       DO 1018 IY=1,NYP
       XX=(IX-1)*DXX
       YY=(IY-1)*DYY
       IF(KBLELE.EQ.0) XX=HCSI(IX)
       IF(KBLELE.EQ.0) YY=HETA(IY)
       GO TO (1031,1032,1033,1034),LBLELE
 1031  CONTINUE
       CSI=XX
       ETA=YY
       GO TO 1013
 1032  CONTINUE
       CSI=XX*XX
       ETA=1.-(1.-YY)**2
       GO TO 1013
 1033  CONTINUE
       CSI=XX
       ETA=1.-(1.-YY)**2
       GO TO 1013
 1034  CONTINUE
       CSI=XX*XX
       ETA=YY
 1013  CONTINUE
       BCHORD=XBTE-XBLE
       XLEZ=XBLE
       XTEZ=XBTE
       TANBLE=TANLEB
       TANBTE=TANTEB
       SPAN=2.*RROTOR
       Y=(RROTOR-YCUT)*ETA+YCUT
       XLE=XLEZ+TANBLE*(Y-YCUT)
       XTE=XTEZ+TANBTE*(Y-YCUT)
       FCHORD=XTE-XLE
       X=XLE+FCHORD*CSI
C
C
       GO TO (1051,1052,1053),KBLSHP
 1051  CONTINUE
C
C       FOR CIRCULAR BICONVEX
C
       XC=0.5*(XLE+XTE)
       PL=0.5*(XTE-XLE)
       TAUBL=.050
       TAU=TAUBL
       H=TAU*PL
       ATAU=2.*H
       ETACR=1.-ATAU/SPAN
       XXC=X-XC
       Z=0.
       IF(H.EQ.0..OR.IY.EQ.NYP.OR.IX.EQ.1.OR.IX.EQ.NXP)GO TO 115
       Z=SIGNZ*(SQRT(((PL*PL+H*H)/(2.*H))**2-XXC**2)-(PL*PL-H*H)/(2.*H))
       IF(ETA.GE.ETACR)Z=Z*SQRT(1.-((ETA-ETACR)*SPAN/ATAU)**2)
       GO TO 115
 1052  CONTINUE
       TAUBAR=TAU*.75*SQRT(3.)*(XTEZ-XLEZ)
```

```
      Z=SIGNZ*TAUBAR*SQRT(CSI)*(1.-CSI)*SQRT(1.-ETA**2)
      GO TO 115
 1053 CONTINUE
      Z=SIGNZ*4.*TAU*(XTEZ-XLEZ)*CSI*(1.-CSI)*SQRT(1.-ETA**2)
  115 CONTINUE
C
      IXY=IX+(IY-1)*NXP
      IS=KS
      IF(IMULT.EQ.2)IS=KS+1
      INODE=NOECT(IXY,IS)
      XK(1,INODE)=X
      XK(2,INODE)=Y*SIGNY
      XK(3,INODE)=Z+ZHUBCR
C
      AZIM=AZIMUTH*PI/180.
      GO TO (301,302),ITWIST
C
  301 CONTINUE
      PITCHR=RPITCH*PI/180.
      PITCHT=(RPITCH+TWIST)*PI/180.
      X1=YCUT
      X2=RROTOR
      XX=XK(1,INODE)
      YY=XK(2,INODE)
      ZZ=XK(3,INODE)
      C1=(YY-X2)/(X1-X2)
      C2=(YY-X1)/(X2-X1)
      DX=X2-X1
      PITCH=C1*PITCHR+C2*PITCHT
      GO TO 303
  302 CONTINUE
      PITCHR=RPITCH*PI/180.
      PIT75=(THET75+THET1C*COS(AZIM)+THET1S*SIN(AZIM))*PI/180.
      X1=YCUT
      X2=.75*RROTOR
      XX=XK(1,INODE)
      YY=XK(2,INODE)
      ZZ=XK(3,INODE)
      C1=(YY-X2)/(X1-X2)
      C2=(YY-X1)/(X2-X1)
      DX=X2-X1
      PITCH=C1*PITCHR+C2*PIT75
  303 CONTINUE
C
C BLADE TWIST
C
      COSPIT=COS(PITCH)
      SINPIT=SIN(PITCH)
C
      XK1=XK(1,INODE)
      XK3=XK(3,INODE)
      XK(1,INODE)= XK1*COSPIT+XK3*SINPIT
      XK(3,INODE)=-XK1*SINPIT+XK3*COSPIT
C
C CONING ANGLE
C
      CONE=CONING*PI/180.
```

```
      COSC=COS(CONE)
      SINC=SIN(CONE)
C
      XK2=XK(2,INODE)
      XK3=XK(3,INODE)
      XK(2,INODE)= XK2*COSC-XK3*SINC
      XK(3,INODE)= XK2*SINC+XK3*COSC
C
C AZIMUTH
C
      HZIM=(AZIMUTH-90.)*PI/180.
      COSHZ=COS(HZIM)
      SINHZ=SIN(HZIM)
C
      XK1=XK(1,INODE)
      XK2=XK(2,INODE)
      XK(1,INODE)=XK1*COSHZ-XK2*SINHZ
      XK(2,INODE)= XK1*SINHZ+XK2*COSHZ
C
      ANG=2.*PI/KBLADE
      ANGR=ANG*(IB-1)
C
      XK1=XK(1,INODE)
      XK2=XK(2,INODE)
C
      XK(1,INODE)= XK1*COS(ANGR)-XK2*SIN(ANGR)
      XK(2,INODE)= XK1*SIN(ANGR)+XK2*COS(ANGR)
C
      WRITE(6,55)IB,IMULT,IXY,IS,X,Y,Z
   55 FORMAT(10X,*IB=*,I5,2X,*IMULT=*,I5,2X,*IXY=*,I5,2X,*IS=*,I5,2X,
     1 *XYZ=*,3(E12.6,2X))
 1010 CONTINUE
 1097 CONTINUE
 1098 CONTINUE
 1099 CONTINUE
C
      WRITE(6,60)
   60 FORMAT(10X,*=== END OF COORDT ===*)
C
      RETURN
      END
```

```
C
      SUBROUTINE CHECK(NELEM,NXMAX,NYMAX,NTMAX)
      COMMON/ZZZ1/NX(34),NY(34),NXY(34),KSYMMY,KSYMMZ,NSYMMY,NSYMMZ
      COMMON/ZZZ2/NSEX,NSBODY,NS,NT(34),ISFACE(34),KNORML(34),KWAKES(34)
      COMMON/ZZZ3/NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,NSHAFT,NHUB,NSHANK,
     1 NBLADE
      COMMON/ZZZ4/UMACH,OMEGA,ALFA,ABETA
      COMMON/ZZZ5/XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      COMMON/ZZZ6/XNOSE,XBD1,XBD2,XTAIL
      COMMON/ZZZ7/YNOSE,YBD1,YBD2,YTAIL
      COMMON/ZZZ8/ZNOSE,ZBD1,ZBD2,ZTAIL
      COMMON/ZZZ9/RYBD1,RZBD1,RYBD2,RZBD2
      COMMON/ZZZ10/RSHAFT,LSHAFT,RSHANK,LSHANK
      COMMON/ZZZ11/XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
      COMMON/ZZZ12/RROTOR,BCHORD,TAUBL,ALFAB
      COMMON/ZZZ13/THET75,THET1C,THET1S,CONING,AZIMUTH
      COMMON/ZZZ14/KBLADE,TANLEB,TANTEB,XBLE,XBTE,KROTORS(34)
      COMMON/ZZZ15/VSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAU,ZVTAIL
      COMMON/ZZZ16/NWAKPY,NWAKHB,NWAKSK,NWAKBL
      COMMON/ZZZ17/WAKLPY,WAKLHB,WAKLSK,WAKLBL
      COMMON/ZZZ18/WANGPY,WANGHB,WANGSK,WANGBL
      COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
      COMMON/ZZZ20/PI
      COMMON/ZZZ21/KPY1,KPY2
      COMMON/ZZZ22/KNSELE,KNSSHP,KNSTYP
      COMMON/ZZZ23/KBDELE,KBDSHP,KBDTYP
      COMMON/ZZZ24/KTNELE,KTNSHP,KTNTYP
      COMMON/ZZZ25/KPYELE,KPYSHP,KPYTYP
      COMMON/ZZZ26/KVTELE,KVTSHP,KVTTYP
      COMMON/ZZZ27/KSHELE,KSHSHP,KSHTYP
      COMMON/ZZZ28/KHBELE,KHBSHP,KHBTYP
      COMMON/ZZZ29/KSKELE,KSKSHP,KSKTYP
      COMMON/ZZZ30/KBLELE,KBLSHP,KBLTYP
      COMMON/ZZZ31/NSTAG,NVORT,NSPIRAL,SPIRAL
      REAL LSHAFT,LSHANK
C
      DO 100 IS=1,NS
      IF(NX(IS).GT.NXMAX) CALL DEBUG(300)
      IF(NY(IS).GT.NYMAX) CALL DEBUG(300)
  100 CONTINUE
      IF(NELEM.GT.NTMAX) CALL DEBUG(500)
      WRITE(6,60)
   60 FORMAT(10X,"--- END OF CHECK --- ")
      RETURN
      END
```

```
C
      SUBROUTINE PREPRO(NNODE,NXYMP,NOFCT,NELEM,NTWAKE)
C
C     THIS SUBROUTINE FUNCTIONED AS A PRE-PROCESSER. ON RETURN,
C     THE CO-ORDINATES OF NODES IN THE GLOBAL NUMBERING SYSTEM
C     WILL BE RE-CONSTRUCTED TO GIVE CO-ORDINATES IN THE LOCAL
C     NUMBERING SYSTEM FOR INDIVIDUAL SURFACES.
C
C
      INTEGER PP,PM,MP,MM
      DIMENSION NOFCT(NXYMP,34)
      COMMON/ZZZ1/NX(34),NY(34),NXY(34),KSYMMY,KSYMMZ,NSYMMY,NSYMMZ
      COMMON/ZZZ2/NSFX,NSBODY,NS,NT(34),ISFACE(34),KNORML(34),KWAKES(34)
      COMMON/ZZZ3/NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,NSHAFT,NHUB,NSHANK,
     1 NBLADE
      COMMON/ZZZ4/UMACH,OMEGA,ALFA,ABETA
      COMMON/ZZZ5/XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      COMMON/ZZZ6/XNOSE,XBD1,XBD2,XTAIL
      COMMON/ZZZ7/YNOSE,YBD1,YBD2,YTAIL
      COMMON/ZZZ8/ZNOSE,ZBD1,ZBD2,ZTAIL
      COMMON/ZZZ9/RYBD1,RZBD1,RYBD2,RZBD2
      COMMON/ZZZ10/RSHAFT,LSHAFT,RSHANK,LSHANK
      COMMON/ZZZ11/XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
      COMMON/ZZZ12/RROTOR,BCHORD,TAUBL,ALFAR
      COMMON/ZZZ13/THET75,THET1C,THET1S,CONING,AZIMUTH
      COMMON/ZZZ14/KBLADE,TANLEB,TANTEB,XBLE,XBTE,KROTORS(34)
      COMMON/ZZZ15/VSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAU,ZVTAIL
      COMMON/ZZZ16/NWAKPY,NWAK4B,NWAKSK,NWAKBL
      COMMON/ZZZ17/WAKLPY,WAK4B,WAKLSK,WAKLBL
      COMMON/ZZZ18/WANGPY,WANG4B,WANGSK,WANGBL
      COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
      COMMON/ZZZ20/PI
      COMMON/ZZZ21/KPYL1,KPYL2
      COMMON/ZZZ22/KNSELE,KNS4P,KNSTYP
      COMMON/ZZZ23/KBDELE,KBD4P,KBDTYP
      COMMON/ZZZ24/KTNELE,KTN4P,KTNTYP
      COMMON/ZZZ25/KPYELE,KPY4P,KPYTYP
      COMMON/ZZZ26/KVTELE,KVT4P,KVTTYP
      COMMON/ZZZ27/KSHELE,KSH4P,KSHTYP
      COMMON/ZZZ28/KHBELE,KHB4P,KHBTYP
      COMMON/ZZZ29/KSKELE,KSK4P,KSKTYP
      COMMON/ZZZ30/KBLELE,KBL4P,KBLTYP
      COMMON/ZZZ31/NSTAG,NVORT,NSPIRAL,SPIRAL
C
C
C     DO 24 I=1,NS
C24   WRITE(6,234)NX(I),NY(I),NT(I),KNORML(I),ISFACE(I)
CC
      MULT=1
      IF (KSYMMZ.EQ.0) MULT=2
      MULTY=1
      IF(KSYMMY.EQ.0)MULTY=2
CC
CC
CC
CC
      NTBODY=NBODY1+NBODY2+NBODY3
```

```
CC
      NODEX=0
      NODEU=0
      IF(NTBODY.EQ.0) GO TO 10
      NODEX=1
      DO 20 I=1,NTBODY
   20 NODEX=NODEX+NX(I)
   10 CONTINUE
CC
      IF(NTBODY.NE.0)
     1NODEU=NODEU+NODEX*(NY(NTBODY)+1) -(NTBODY-1)*NY(NTBODY)
CC
CC  NODEX=NUMBER OF NODES ALONG AIRCRAFT CENTERLINE
CC
CC    NODEU=NUMBER OF NODES ON UPPER RHS FUSELAGE BODY
CC
CC
CC
      IS=0
      NODE0=0
      NLAST=0
C
      IF(NBODY1.EQ.0)GO TO 99
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 80 IY=1,NYP
      DO 80 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IX.EQ.1.AND.IY.GT.1)GO TO 85
      NODE0=NODE0+1
85    CONTINUE
      INODE=NODE0
      IF(IX.EQ.1)INODE=1
      NOECT(IXY,IS)=INODE
80    CONTINUE
99    CONTINUE
C
      NLAST=NODE0
      IF(NBODY2.EQ.0)GO TO 199
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 180 IY=1,NYP
      DO 180 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IX.EQ.1)GO TO 185
      NODE0=NODE0+1
185   CONTINUE
      INODE=NODE0
      IF(IX.EQ.1)INODE=(NX(1)+1)+(IY-1)*NX(1)
      NOECT(IXY,IS)=INODE
180   CONTINUE
199   CONTINUE
C
```

```
      NLAST=NODE0
      IF(NBODY3.EQ.0)GO TO 299
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 280 IY=1,NYP
      DO 280 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IX.EQ.1)GO TO 285
      IF(IX.EQ.NXP.AND.IY.GT.1)GO TO 285
      NODE0=NODE0+1
285   CONTINUE
      INODE=NODE0
      IF(IX.EQ.1)INODE=
     1 NX(1)*(NY(1)+1)+1+
     2 NX(2)+(IY-1)*NX(2)
      IF(IX.EQ.NXP)INODE=
     1 NX(1)*(NY(1)+1)+1+
     2 NX(2)*(NY(2)+1)+
     3 NX(3)
      NOECT(IXY,IS)=INODE
280   CONTINUE
299   CONTINUE
C
      NLAST=NODE0
C
      IF(NPYLON.EQ.0)GO TO 399
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 380 IY=1,NYP
      DO 380 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IX.EQ.1.AND.IY.GT.1)GO TO 385
      IF(IX.EQ.NXP)GO TO 385
      NODE0=NODE0+1
385   CONTINUE
      INODE=NODE0
      IF(IX.EQ.1)INODE=
     1 NLAST+1
      IF(IX.EQ.NXP)INODE= NX(1)*(NY(1)+1)+1+NYP-(IY-1)
      NOECT(IXY,IS)=INODE
380   CONTINUE
399   CONTINUE
      NLAST=NODE0
C
      IF(KSYMMZ.NE.0)GO TO 499
      IF(NBODY1.EQ.0) GO TO 433
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 480 IY=1,NYP
      DO 480 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
```

```
      IF(IX.EQ.1) GO TO 485
      IF(IY.EQ.NYP) GO TO 485
      NODE0=NODE0+1
485   CONTINUE
      INODE=NODE0
      IF(IX.EQ.1)INODE=1
      IF(IX.NE.1.AND.IY.EQ.NYP)INODE=
     1 NX(1)*NY(1)+IX
      NOFCT(IXY,IS)=INODE
480   CONTINUE
499   CONTINUE
C
      NLAST=NODE0
C
      IF(KSYMMZ.NE.0) GO TO 599
      IF(NBODY2.EQ.0)GO TO 599

      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 580 IY=1,NYP
      DO 580 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IX.EQ.1)GO TO 585
      IF(IY.EQ.NYP)GO TO 585
      NODE0=NODE0+1
585   CONTINUE
      INODE=NODE0
      IF(IX.EQ.1.AND.IY.NE.NYP)INODE=
     1 NLAST-NX(1)*(NY(1)-2)-(NX(1)-1)-1+(IY-1)*NX(1)
      IF(IX.EQ.1.AND.IY.EQ.NYP)INODE=
     1 NX(1)*(NY(1)+1)+1
      IF(IY.EQ.NYP.AND.IX.NE.1)INODE=
     1 NX(1)*(NY(1)+1)+1+
     2 NX(2)*NY(2)-1+IX
      NOFCT(IXY,IS)=INODE
580   CONTINUE
599   CONTINUE
C
      NLAST=NODE0
      IF(KSYMMZ.NE.0)GO TO 699
      IF(NBODY3.EQ.0)GO TO 699
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 680 IY=1,NYP
      DO 680 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IX.EQ.1) GO TO 685
      IF(IY.EQ.NYP)GO TO 685
      IF(IX.EQ.NXP)GO TO 685
      NODE0=NODE0+1
685   CONTINUE
      INODE=NODE0
      IF(IX.EQ.1.AND.IY.NE.NYP)INODE=
```

```
      1 NLAST-NX(2)*(NY(2)-2)-(NX(2)-1)-1+(IY-1)*NX(2)
       IF(IY.EQ.NYP.AND.(IX.NE.1.OR.IX.NE.NXP))INODE=
      1 NX(1)*(NY(1)+1)+1+
      2 NX(2)*(NY(2)+1)+
      3 (NX(3)-1)*NY(3)+1+(IX-1)
       IF(IX.EQ.NXP)INODE=
      1 NX(1)*(NY(1)+1)+1+
      2 NX(2)*(NY(2)+1)+
      3 NX(3)
       IF(IX.EQ.1 .AND. IY.EQ.NYP)INODE=
      1 NX(1)*(NY(1)+1)+1+NX(2)*(NY(2)+1)
       NOFCT(IXY,IS)=INODE
680    CONTINUE
699    CONTINUE
C
       NLAST=NODE0
       NODET=NLAST
       IF(NVTAIL.EQ.0)GO TO 79
       IS=IS+1
       NXP=NX(IS)+1
       NYP=NY(IS)+1
       DO 780 IY=1,NYP
       DO 780 IX=1,NXP
       IXY=IX+(IY-1)*NXP
C
       NODE0=NODE0+1
       INODE=NODE0+NLAST
       NOFCT(IXY,IS)=INODE
780    CONTINUE
799    CONTINUE
C
       NLAST=NODE0
       IF(KSYMMY.NE.0) GO TO 899
       IF(NBODY1.EQ.0)GO TO 899
       IS=IS+1
       NXP=NX(IS)+1
       NYP=NY(IS)+1
       DO 880 IY=1,NYP
       DO 880 IX=1,NXP
       IXY=IX+(IY-1)*NXP
C
       IF(IX.EQ.1) GO TO 885
       IF(IY.EQ.1) GO TO 885
       NODE0=NODE0+1
885    CONTINUE
       INODE=NODE0
       IF(IX.EQ.1)INODE=1
       IF(IY.EQ.1)INODE=IX
       NOFCT(IXY,IS)=INODE
880    CONTINUE
899    CONTINUE
C
       NLAST=NODE0
       IF(KSYMMY.NE.0) GO TO 999
       IF(NBODY2.EQ.0)GO TO 999
       IS=IS+1
       NXP=NX(IS)+1
```

```
      NYP=NY(IS)+1
      KPYL1=1
      KPYL2=2
      K1=KPYL1+2
      K2=K1+NX(4)-2
      DO 980 IY=1,NYP
      DO 980 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(NPYLON.NE.0) GO TO 950
      IF(IX.EQ.1)GO TO 985
      IF(IY.EQ.1)GO TO 985
      NODE0=NODE0+1
985   CONTINUE
      INODE=NODE0
      IF(IX.EQ.1)INODE=
     1 NLAST-NX(1)*(NY(1)-1)-(NX(1)-1)-1+(IY-1)*NX(1)
      IF(IY.EQ.1)INODE=
     2 NX(1)*(NY(1)+1)+1+(IX-1)
      IF(IX.EQ.1.AND.IY.EQ.1)INODE=
     1 NX(1)+1
      GO TO 949
  950 CONTINUE
      IF(IX.EQ.1) GO TO 951
      IF(IY.EQ.1.AND.(IX.LT.K1.OR.IX.GT.K2)) GO TO 951
      NODE0=NODE0+1
  951 CONTINUE
      INODE=NODE0
      IF(IX.EQ.1)INODE=NLAST-NX(1)*(NY(1)-1)-(NX(1)-1)-1+(IY-1)*NX(1)
      IF(IY.EQ.1.AND.(IX.LT.K1.OR.IX.GT.K2))INODE=
     1 NX(1)*(NY(1)+1)+1+(IX-1)
      IF(IX.EQ.1.AND.IY.EQ.1)INODE=NX(1)+1
  949 CONTINUE
      NOFCI(IXY,IS)=INODE
980   CONTINUE
990   CONTINUE
C
      NLAST=NODE0
      IF(KSYMMY.NE.0) GO TO 1039
      IF(NBOCY3.EQ.0)GO TO 1033
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 1080 IY=1,NYP
      DO 1080 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IX.EQ.1)GO TO 1085
      IF(IY.EQ.1)GO TO 1085
      IF(IX.EQ.NXP)GO TO 1085
      NODE0=NODE0+1
1085  CONTINUE
      INODE=NODE0
      IF(IX.EQ.1)INODE=
     1 NLAST-NX(2)*(NY(2)-1)+(IY-2)*NX(2)
      IF(IY.EQ.1)INODE=
     1 NX(1)*(NY(1)+1)+1+NX(2 *(NY(2)+1)+(IX-1)
```

```
      IF(IX.EQ.1.AND.IY.EQ.1)INODE=
     1 NX(1)*(NY(1)+1)+1+NX(2)
      IF(IX.EQ.NXP) INODE=
     1 NX(1)*(NY(1)+1)+1+
     2 NX(2)*(NY(2)+1)+NX(3)
      NOECT(IXY,IS)=INODE
 1080 CONTINUE
 1099 CONTINUE
C
      NLAST=NODE0
      IF(KSYMMY.NE.0) GO TO 1199
      IF(NPYLON.EQ.0)GO TO 1199
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 1180 IY=1,NYP
      DO 1180 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IY.EQ.1)GO TO 1185
      IF(IX.EQ.1.OR.(IX.EQ.NXP))GO TO 1185
      IF(IY.EQ.NYP)GO TO 1185
      NODE0=NODE0+1
 1185 CONTINUE
      INODE=NODE0
      IF(IY.EQ.1)INODE=NODEU+
      IF(IX.EQ.1)INODE=NODEU+1
      IF(IY.EQ.NYP.AND.IX.NE.1)INODE=NODEU+1+(NXP-2)*(NYP-1)+1+(IX-2)
      IF(IX.EQ.NXP) INODE=NLAST-(NX(3)-1)*NY(3)-NX(2)*NY(2)+1-(IY-1)
      IF(IY.EQ.1.AND.IX.EQ.NXP)INODE=NX(1)*(NY(1)+1)+1+NX(4)+1
      IF(IY.EQ.NYP.AND.IX.EQ.NXP)INODE=NX(1)*(NY(1)+1)+1+1
      NOECT(IXY,IS)=INODE
 1180 CONTINUE
 1199 CONTINUE
C
      NLAST=NODE0
      IF(KSYMMZ.NE.0) GO TO 1299
      IF(NBODY1.EQ.0)GO TO 1299
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 1280 IY=1,NYP
      DO 1280 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IY.EQ.1)GO TO 1285
      IF(IX.EQ.1)GO TO 1285
      IF(IY.EQ.NYP)GO TO 1285
      NODE0=NODE0+1
 1285 CONTINUE
      INODE=NODE0
      PSS=0.
      IF(NPYLON.EQ.0)PSS=1.
      IF(PSS.EQ.1.)GO TO 1290
      IF(IX.EQ.1)INODE=1
      IF(IX.NE.1.AND.IY.EQ.1)INODE=
     1 NODEU+
```

```
      2 (NX(4)-1)*(NY(4)+1)+IX
       IF(IX.NE.1.AND.IY.EQ.NY2) INODE=NLAST-
      1 NX(4)*(NY(4)-1)-(NX(3)-1)*NY(3)-
      2 NX(2)*NY(2)-NX(1)+(IX-1)
        GO TO 1250
 1290 CONTINUE
        IF(IX.EQ.1)INODE=1
        IF(IX.NE.1.AND.IY.EQ.1)INODE=
      1 NODEU+(IX-1)
        IF(IX.NE.1.AND.IY.EQ.NY2) INODE=
      1NODEU+NX(1)*NY(1)+NX(2)*NY(2)+(NX(3)-1)*NY(3)+
      2 NX(1)*(NY(1)-1)+(IX-1)
 1250 CONTINUE
        NOECT(IXY,IS)=INODE
 1280  CONTINUE
 1299  CONTINUE
C
        NLAST=NODE0
        IF(KSYMMZ.NE.0)GO TO 1399
        IF(NBODY2.EQ.0)GO TO 1393
        IS=IS+1
        NXP=NX(IS)+1
        NYP=NY(IS)+1
        DO 1380 IY=1,NYP
        DO 1380 IX=1,NXP
        IXY=IX+(IY-1)*NXP
C
        IF(IY.EQ.1)GO TO 1385
        IF(IX.EQ.1)GO TO 1385
        IF(IY.EQ.NYP)GO TO 1385
        NODE0=NODE0+1
 1385  CONTINUE
        INODE=NODE0
        PSS=0.
        IF(NPYLON.EQ.0)PSS=1.
        IF(PSS.EQ.1.)GO TO 1390
        IF(IX.EQ.1.AND.(IY.NE.1.OR.IY.NE.NYP)) INODE=
      1 NLAST-NX(1)*(NY(1)-2)+(IY-2)*NX(1)
        IF(IX.EQ.1.AND.IY.EQ.1)INODE=
      1 NODEU+(NX(4)-1)*(NY(4)+1)+1+NX(1)
        IF(IX.GT.1.AND.IY.EQ.1)INODE=
      1 NODEU+(NX(4)-1)*(NY(4)+1)+1+
      2 NX(1)*NY(1)+(IX-1)
        IF(IX.EQ.1.AND.IY.EQ.NY2)INODE=
      1 NLAST-NX(1)*(NY(1)-1)-NX(4)*(NY(4)-1)-
      2 (NX(3)-1)*NY(3)-NX(2)*NY(2)
        IF(IX.GT.1.AND.IY.EQ.NYP)INODE=
      1 NLAST-NX(1)*(NY(1)-1)-
      2 (NX(4)-1)*(NY(4)-1)-(NX(3)-1)*NY(3)-
      3 NX(2)+(IX-1)
        GO TO 1350
 1390 CONTINUE
        IF(IX.EQ.1.AND.(IY.NE.1.OR.IY.NE.NYP)) INODE=
      1 NLAST-NX(1)-(NY(1)-1)+(IY-2)*NX(1)
      2 +NX(1)
        IF(IX.EQ.1.AND.IY.EQ.1)INODE=
      1 NODEU+NX(1)
```

```
      IF(IY.EQ.1.AND.IX.NE.1)INODE=
     1 NODEU+NX(1)*NY(1)+(IX-1)
      IF(IX.EQ.1.AND.IY.EQ.NYP) INODE=
     1 NLAST-NX(1)*(NY(1)-1)-(NX(3)-1)*NY(3)-NX(2)*NY(2)
      IF(IX.NE.1.AND.IY.EQ.NYP)INODE=
     1 NLAST-NX(1)*(NY(1)-1)-(NX(3)-1)*NY(3)-NX(2)+(IX-1)
 1350 CONTINUE
      NOECT(IXY,IS)=INODE
 1360 CONTINUE
 1390 CONTINUE
      NLAST=NODE0
      IF(NBODY3.EQ.0)GO TO 1433
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 1480 IY=1,NYP
      DO 1480 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IX.EQ.1)GO TO 1485
      IF(IY.EQ.1)GO TO 1485
      IF(IY.EQ.NYP)GO TO 1485
      IF(IX.EQ.NXP)GO TO 1485
      NODE0=NODE0+1
 1485 CONTINUE
      INODE=NODE0
      PSS=0.
      IF(NPYLON.EQ.0)PSS=1.
      IF(PSS.EQ.1.)GO TO 1490
      IF(IX.EQ.1)INODE=NLAST-
     1 NX(2)+(IY-2)*NX(2)
      IF(IX.EQ.1.AND.IY.EQ.1)INODE=
     1 NODEU+(NX(4)-1)*(NY(4)+1)+1+
     2 NX(1)*NY(1)+NX(2)
      IF(IX.NE.1.AND.IY.EQ.1)INODE=
     1 NODEU+(NX(4)-1)*(NY(4)+1)+1+NX(1)*NY(1)+
     2 NX(2)*NY(2)+(IX-1)
      IF(IY.EQ.NYP.AND.IX.EQ.1)INODE=
     1 NLAST-NX(2)*(NY(2)-1)-NX(1)*(NY(1)-1)-
     2 (NX(4)-1)*(NY(4)+1)-NX(3)*NY(3)
     3 +NX(3)
      IF(IY.EQ.NYP.AND.IX.NE.1)INODE=
     1 NLAST-NX(2)*(NY(2)-1)-NX(1)*(NY(1)-1)-
     2 (NX(4)-1)*(NY(4)-1)-(NX(3)-1)+(IX-1)
      IF(IX.EQ.NXP)INODE=
     1 NX(1)*(NY(1)+1)+NX(2)*(NY(2)+1)+NX(3)+1
      GO TO 1450
 1490 CONTINUE
      IF(IY.EQ.1)INODE=
     1 NODEU+NX(1)*NY(1)+NX(2)*NY(2)+(IX-1)
      IF(IY.EQ.NYP)INODE=
     1 NLAST-NX(2)*(NY(2)-1)-NX(1)*(NY(1)-1)-NX(3)+IX
      IF(IX.EQ.NXP)INODE=
     1 NODEU-(NX(3)-1)*NY(3)
      IF(IX.EQ.1)INODE=
     1 NLAST-NX(2)-(NX(2)-1)-1+(IY-2)*NX(2)
     2  +NX(2)
```

```
      IF(IX.EQ.1.AND.IY.EQ.1)INODE=
     1 NODEU+NX(1)*NY(1)+NX(2)
      IF(IX.EQ.1.AND.IY.EQ.NYP) INODE=
     1 NLAST-NX(2)*(NY(2)-1)-NX(1)*(NY(1)-1)-(NX(3)-1)*NY(3)
 1450 CONTINUE
      NOFCT(IXY,IS)=INODE
 1400 CONTINUE
 1499 CONTINUE
      NLAST=NODE0
      IF(NYTAIL.EQ.0)GO TO 1599
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 1500 IY=1,NYP
      DO 1500 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IX.EQ.1.OR.IX.EQ.NXP) GO TO 1585
      IF(IY.EQ.NYP) GO TO 1585
      NODE0=NODE0+1
 1585 CONTINUE
      INODE=NODE0
      IF(IX.EQ.1)INODE=
     1 NODET+(IY-1)*(NX(0)+1)
      IF(IX.EQ.NXP) INODE=
     1 NODET+1+NX(0)+(IY-1)*(NX(0)+1)
      IF(IY.EQ.NYP) INODE=
     1 NODET+(NX(0)+1)*NY(0)+IX
      NOFCT(IXY,IS)=INODE
 1500 CONTINUE
 1599 CONTINUE
C
      NLAST=NODE0
      NBODY=NODE0
      IF(NSHAFT.EQ.0)GO TO 16-9
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 1600 IY=1,NYP
      DO 1600 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      NODE0=NODE0+1
      INODE=NODE0
      NOFCT(IXY,IS)=INODE
 1600 CONTINUE
 1699 CONTINUE
C
      NLAST=NODE0
      IF(KSYMMY.NE.0) GO TO 1739
      IF(NSHAFT.EQ.0)GO TO 1799
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 1700 IY=1,NYP
      DO 1700 IX=1,NXP
      IXY=IX+(IY-1)*NXP
```

```
C
      IF(IY.EQ.1.OR.IY.EQ.NYP)GO TO 1785
      NODE8=NODE8+1
 1785 CONTINUE
      INODE=NODE8
      IF(IY.EQ.1)INODE=
     1 NBODY+IX
      IF(IY.EQ.NYP)INODE=
     1 NBODY+(NX(IS)+1)*NY(IS)+IX
      NOFCT(IXY,IS)=INODE
 1780 CONTINUE
 1790 CONTINUE
C
      NLAST=NODE8
      IF(NHUB.EQ.0)GO TO 1899
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 1880 IY=1,NYP
      DO 1880 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IX.EQ.1.AND.IY.GT.1)GO TO 1885
      NODE8=NODE8+1
 1885 CONTINUE
      INODE=NODE8
      IF(IX.EQ.1)INODE=NLAST+1
      NOFCT(IXY,IS)=INODE
 1880 CONTINUE
 1899 CONTINUE
C
      NLAST=NODE8
      IF(KSYMMZ.NE.0) GO TO 1999
      IF(NHUB.EQ.0)GO TO 1999
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 1980 IY=1,NYP
      DO 1980 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IX.EQ.1.AND.IY.GT.1)GO TO 1985
      IF(IX.EQ.NXP)GO TO 1985
      NODE8=NODE8+1
 1985 CONTINUE
      INODE=NODE8
      IF(IX.EQ.1)INODE=NBODY+
     1 (NX(15)+1)*(NY(15)+1)+
     2 (NX(16)+1)*(NY(16)-1)+
     3 NX(17)*(NY(17)+1)+1+1
      IF(IX.EQ.NXP)INODE=NBODY+
     1 (NX(15)+1)*(NY(15)+1)+
     2 (NX(16)+1)*(NY(16)-1)+
     3 (NX(17)+1)+(IY-1)*NX(17)
      NOFCT(IXY,IS)=INODE
 1980 CONTINUE
 1999 CONTINUE
```

```
C
      NLAST=NODEB
      IF(KSYMMY.NE.0) GO TO 2199
      IF(NHUB.EQ.0)GO TO 2099
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 2080 IY=1,NYP
      DO 2080 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IX.EQ.1)GO TO 2085
      IF(IY.EQ.1.OR.IY.EQ.NYP)GO TO 2085
      NODEB=NODEB+1
 2085 CONTINUE
      INODE=NODEB
      IF(IX.EQ.1)INODE=NBODY+
     1 (NX(15)+1)*(NY(15)+1)+
     2 (NX(16)+1)*(NY(16)-1)+
     3 1
      IF(IY.EQ.1.AND.IX.NE.1)INODE=
     1 NBODY+(NX(15)+1)*(NY(1 )+1)+
     2 (NX(16)+1)*(NY(16)-1)+
     3 IX
      IF(IY.EQ.NYP.AND.IX.NE.1) INODE=
     1 NBODY+(NX(15)+1)*(NY(1 )+1)+
     2 (NX(16)+1)*(NY(16)-1)+
     3 NX(17)*NY(17)+IX
      NOFCT(IXY,IS)=INODE
 2080 CONTINUE
 2099 CONTINUE
C
      NLAST=NODEB
      IF(KSYMMZ.NE.0) GO TO 2139
      IF(NHUB.EQ.0)GO TO 2199
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 2180 IY=1,NYP
      DO 2180 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IX.EQ.1)GO TO 2185
      IF(IY.EQ.1.OR.IY.EQ.NYP)GO TO 2185
      IF(IX.EQ.NXP)GO TO 2185
      NODEB=NODEB+1
 2185 CONTINUE
      INODE=NODEB
      IF(IX.EQ.1)INODE=NBODY+
     1 (NX(15)+1)*(NY(15)+1)+
     2 (NX(16)+1)*(NY(16)-1)+
     3 NX(17)*(NY(17)+1)+1+
     4 1
      IF(IY.EQ.1.AND.IX.NE.1)INODE=NBODY+
     1 (NX(15)+1)*(NY(15)+1)+
     2 (NX(16)+1)*(NY(16)-1)+
     3 NX(17)*(NY(17)+1)+1+
```

```
      4 IX
        IF(IY.EQ.NYP.AND.IX.NE.1)INODE=NBODY+
      1 (NX(15)+1)*(NY(15)+1)+
      2 (NX(16)+1)*(NY(16)-1)+
      3 NX(17)*(NY(17)+1)+1+
      4 (NX(18)-1)*NY(18)+IX
        IF(IX.EQ.NXP)INODE=NBODY+
      1 (NX(15)+1)*(NY(15)+1)+
      2 (NX(16)+1)*(NY(16)-1)+
      3 NX(17)*(NY(17)+1)+1+
      4 (NX(18)-1)*(NY(18)+1)+1+
      5 NX(18)+(IY-2)*NX(18)
        IF(IX.EQ.NXP.AND.IY.EQ.NYP)INODE=
      1 NBODY+
      2 (NX(15)+1)*(NY(15)+1)+
      3 (NX(16)+1)*(NY(16)-1)+
      4 NX(17)*(NY(17)+1)+1
        IF(IX.EQ.NXP.AND.IY.EQ.1)INODE=
      1 NBODY+
      2 (NX(15)+1)*(NY(15)+1)+
      3 (NX(16)+1)*(NY(16)-1)+NX(17)
      4 +1
        NOFCT(IXY,IS)=INODE
 2180   CONTINUE
 2199   CONTINUE
C
        NLAST=NODE0
        IF(NSHANK.EQ.0)GO TO 2299
        IS=IS+1
        NXP=NX(IS)+1
        NYP=NY(IS)+1
        DO 2280 IY=1,NYP
        DO 2280 IX=1,NXP
        IXY=IX+(IY-1)*NXP
C
        IF(IY.EQ.NYP)GO TO 2285
        NODE0=NODE0+1
 2285   CONTINUE
        INODE=NODE0
        IF(IY.EQ.NYP)INODE=NLAST+IX
        NOFCT(IXY,IS)=INODE
 2280   CONTINUE
 2299   CONTINUE
C
        NLAST=NODE0
        IF(NBLADE.EQ.0)GO TO 2399
        IS=IS+1
        NXP=NX(IS)+1
        NYP=NY(IS)+1
        DO 2380 IY=1,NYP
        DO 2380 IX=1,NXP
        IXY=IX+(IY-1)*NXP
C
        NODE0=NODE0+1
        INODE=NODE0
        NOFCT(IXY,IS)=INODE
 2380   CONTINUE
```

```
 2399 CONTINUE
C
      NLAST=NODE0
      IF(KSYMMZ.NE.0) GO TO 2499
      IF(NBLADE.EQ.0)GO TO 2499
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 2480 IY=1,NYP
      DO 2480 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IX.EQ.1.OR.IX.EQ.NXP)GO TO 2485
      IF(IY.EQ.NYP)GO TO 2485
      NODE0=NODE0+1
 2485 CONTINUE
      INODE=NODE0
      IF(IX.EQ.1)INODE=
     1 NLAST-NXP*NYP+(IY-1)*NXP
     1 +1
      IF(IX.EQ.NXP)INODE=NLAST-NXP*NYP+1+(IY-1)*NXP+NX(IS)
      IF(IY.EQ.NYP)INODE=NLAST-NXP+IX
      NOFCT(IXY,IS)=INODE
 2480 CONTINUE
 2499 CONTINUE
C
      NLAST=NODE0
      NTEMP=NODE0
      IF(NSHANK.EQ.0)GO TO 2599
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 2580 IY=1,NYP
      DO 2580 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IY.EQ.NYP)GO TO 2585
      NODE0=NODE0+1
CC
 2585 CONTINUE
      INODE=NODE0
      IF(IY.EQ.NYP)INODE=NLAST+IX
      NOFCT(IXY,IS)=INODE
 2580 CONTINUE
 2599 CONTINUE
C
      NLAST=NODE0
      IF(NBLADE.EQ.0)GO TO 2699
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 2680 IY=1,NYP
      DO 2680 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      NODE0=NODE0+1
      INODE=NODE0
```

```
      NOFCT(IXY,IS)=INODE
 2680 CONTINUE
 2699 CONTINUE
C
      NLAST=NODE0
      IF(NBLADE.EQ.0)GO TO 2799
      IS=IS+1
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 2780 IY=1,NYP
      DO 2780 IX=1,NXP
      IXY=IX+(IY-1)*NXP
C
      IF(IX.EQ.1.OR.IX.EQ.NXP)GO TO 2785
      IF(IY.EQ.NYP)GO TO 2785
      NODE0=NODE0+1
 2785 CONTINUE
      INODE=NODE0
      IF(IX.EQ.1)INODE=NLAST-NXP*NYP+(IY-1)*NXP
     1 +1
      IF(IX.EQ.NXP) INODE=NLAST-NXP*NYP+1+(IY-1)*NXP+NX(IS)
      IF(IY.EQ.NYP)INODE=NLAST-NXP+IX
      NOFCT(IXY,IS)=INODE
 2780 CONTINUE
 2799 CONTINUE
      NLAST=NODE0
      NODE=NLAST
CC
CC
C
      IF(KSYMMY.EQ.0)NSYMMY=1
      IF(KSYMMY.NE.0)NSYMMY=2
      IF(KSYMMZ.EQ.0)NSYMMZ=1
      IF(KSYMMZ.NE.0)NSYMMZ=2
C
      NNODE=NODE0
      WRITE(6,4000)
 4000 FORMAT(//10X,6HPREPRO)
      WRITE(6,4001) NNODE
 4001 FORMAT(5X,6HNNODE=,I5)
      DO 100 IS=1,NS
      NXP=NX(IS)+1
      NYP=NY(IS)+1
      DO 100 IY=1,NYP
      DO 100 IX=1,NXP
      IXY=IX+(IY-1)*NXP
      WRITE(6,200)IS,IX,IY,IXY,NOFCT(IXY,IS)
  100 CONTINUE
  200 FORMAT(2X,*IS=*,I5,2X,*IX=*,I5,2X,*IY=*,I5,2X,*IXY=*,I5,2X,
     1 *NOFCT=*,I5)
      RETURN
      END
```

```
      SUBROUTINE GEOMET(NELEM,NXYMP,NOFCT,NODE,XK,NTNODE,KWAKE,KROTOR)
C
C
      COMMON/ZZZ1/NX(34),NY(34),NXY(34),KSYMMY,KSYMMZ,NSYMMY,NSYMMZ
      COMMON/ZZZ2/NSFX,NSBODY,NS,NT(34),ISFACE(34),KNORML(34),KWAKES(34)
      COMMON/ZZZ3/NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,NSHAFT,NHUB,NSHANK,
     1 NBLADE
      COMMON/ZZZ4/UMACH,OMEGA,ALFA,ABETA
      COMMON/ZZZ5/XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      COMMON/ZZZ6/XNOSE,XBD1,XBD2,XTAIL
      COMMON/ZZZ7/YNOSE,YBD1,YBD2,YTAIL
      COMMON/ZZZ8/ZNOSE,ZBD1,ZBD2,ZTAIL
      COMMON/ZZZ9/RYBD1,RZBD1,RYBD2,RZBD2
      COMMON/ZZZ10/RSHAFT,LSHAFT,RSHANK,LSHANK
      COMMON/ZZZ11/XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
      COMMON/ZZZ12/RROTOR,BCHORD,TAUBL,ALFAB
      COMMON/ZZZ13/THET75,THET1C,THET1S,CONING,AZIMUTH
      COMMON/ZZZ14/KBLADE,TANLEB,TANTEB,XBLE,XBTE,KROTORS(34)
      COMMON/ZZZ15/VSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAU,ZVTAIL
      COMMON/ZZZ16/NWAKPY,NWAKHB,NWAKSK,NWAKBL
      COMMON/ZZZ17/WAKLPY,WAKLHB,WAKLSK,WAKLBL
      COMMON/ZZZ18/WANGPY,WANGHB,WANGSK,WANGBL
      COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
      COMMON/ZZZ20/PI
      COMMON/ZZZ21/KPY1,KPY2
      COMMON/ZZZ22/KNSELE,KNSSHP,KNSTYP
      COMMON/ZZZ23/KBDELE,KBDSHP,KBDTYP
      COMMON/ZZZ24/KINELE,KINSHP,KINTYP
      COMMON/ZZZ25/KPYELE,KPYSHP,KPYTYP
      COMMON/ZZZ26/KVTELE,KVTSHP,KVTTYP
      COMMON/ZZZ27/KSHELE,KSHSHP,KSHTYP
      COMMON/ZZZ28/KHBELE,KHBSHP,KHBTYP
      COMMON/ZZZ29/KSKELE,KSKSHP,KSKTYP
      COMMON/ZZZ30/KBLELE,KBLSHP,KBLTYP
      COMMON/ZZZ31/NSTAG,NVORT,NSPIRAL,SPIRAL
      DIMENSION KROTOR(NELEM)
      DIMENSION XK(3,NTNODE),NOFCT(NXYMP,34),KWAKE(NELEM),NODE(4,NELEM)
      REAL LSHAFT,LSHANK
C
C
      NSH=NS
      NHALF=NELEM
      DO 1999 IS=1,NSH
      ISFIX=ISFACE(IS)
      NXX=NX(IS)
      NXP=NXX+1
      NYY=NY(IS)
      DO 999 IX=1,NXX
      DO 999 IY=1,NYY
C
C
      IELEM=IX+NX(IS)*(IY-1)+NT(IS)
      IF(KNORML(IS).EQ.-1)GO TO 906
C
C     --      -+
C     +-      ++
C
```

```
      IXMM=IX
      IXPM=IX+1
      IXMP=IX
      IXPP=IX+1
      IYMM=IY
      IYPM=IY
      IYPP=IY+1
      IYMP=IY+1
C
      GO TO 987
906   CONTINUE
C
C     -+      --
C     ++      +-
C
      IXMM=IX
      IXMP=IX
      IXPP=IX+1
      IXPM=IX+1
      IYMM=IY+1
      IYMP=IY
      IYPP=IY
      IYPM=IY+1
987   CONTINUE
C
      IXYPP=IXPP+(IYPP-1)*NXP
      IXYPM=IXPM+(IYPM-1)*NXP
      IXYMP=IXMP+(IYMP-1)*NXP
      IXYMM=IXMM+(IYMM-1)*NXP
C
      NODE(1,IELEM)=NOFCT(IXYPP,IS)
      NODE(2,IELEM)=NOFCT(IXYPM,IS)
      NODE(3,IELEM)=NOFCT(IXYMP,IS)
      NODE(4,IELEM)=NOFCT(IXYMM,IS)
      KWAKE(IELEM)=0
      KROTOR(IELEM)=0
      IF(KWAKES(IS).GT.0.AND.IX.EQ.NXX)KWAKE(IELEM)=1
      IF(KROTORS(IS).NE.0) KROTOR(IELEM)=1
      WRITE(6,50)IS,IELEM,NODE(1,IELEM),NODE(2,IELEM),NODE(3,IELEM),
     1 NODE(4,IELEM),KWAKE(IELEM),KROTOR(IELEM)
   50 FORMAT(5X,*IS=*,I5,2X,*IELEM=*,I5,2X,*NODE1=*,I5,2X,*NODE2=*,I5,
     1 2X,*NODE3=*,I5,2X,*NODE4=*,I5,2X,*KWAKE=*,I5,2X,*KROTOR=*,I5)
C
999   CONTINUE
1999  CONTINUE
C
      WRITE(6,60)
   60 FORMAT(10X,*=== END OF GEOMET ===*)
      RETURN
      END
```

```
C
      SUBROUTINE VEC123(NELEM,NODE,PC,P1,P2,P3,XK,NNODE)
      COMMON/ZZZ1/NX(34),NY(34),NXY(34),KSYMMY,KSYMMZ,NSYMMY,NSYMMZ
      COMMON/ZZZ2/NSEX,NSBODY,NS,NT(34),ISFACE(34),KNORML(34),KWAKES(34)
      COMMON/ZZZ3/NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,NSHAFT,NHUB,NSHANK,
     1 NBLADE
      COMMON/ZZZ4/UMACH,OMEGA,ALFA,ABETA
      COMMON/ZZZ5/XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      COMMON/ZZZ6/XNOSE,XBD1,XBD2,XTAIL
      COMMON/ZZZ7/YNOSE,YBD1,YBD2,YTAIL
      COMMON/ZZZ8/ZNOSE,ZBD1,ZBD2,ZTAIL
      COMMON/ZZZ9/RYBD1,RZBD1,RYBD2,RZBD2
      COMMON/ZZZ10/RSHAFT,LSHAFT,RSHANK,LSHANK
      COMMON/ZZZ11/XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
      COMMON/ZZZ12/RROTOR,BCHORD,TAUBL,ALFAB
      COMMON/ZZZ13/THET7S,THET1C,THET1S,CONING,AZIMUTH
      COMMON/ZZZ14/KBLADE,TANLEB,TANTEB,XBLE,XBTE,KROTORS(34)
      COMMON/ZZZ15/VSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAU,ZVTAIL
      COMMON/ZZZ16/NWAKPY,NWAKHB,NWAKSK,NWAKBL
      COMMON/ZZZ17/WAKLPY,WAKLHB,WAKLSK,WAKLBL
      COMMON/ZZZ18/WANGPY,WANGHB,WANGSK,WANGBL
      COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
      COMMON/ZZZ20/PI
      COMMON/ZZZ21/KPY1,KPY2
      COMMON/ZZZ22/KNSELE,KNSSHP,KNSTYP
      COMMON/ZZZ23/KBDELE,KBDSHP,KBDTYP
      COMMON/ZZZ24/KTNELE,KTNSHP,KTNTYP
      COMMON/ZZZ25/KPYELE,KPYSHP,KPYTYP
      COMMON/ZZZ26/KVTELE,KVTSHP,KVTTYP
      COMMON/ZZZ27/KSHELE,KSHSHP,KSHTYP
      COMMON/ZZZ28/KHBELE,KHBSHP,KHBTYP
      COMMON/ZZZ29/KSKELE,KSKSHP,KSKTYP
      COMMON/ZZZ30/KBLELE,KBLSHP,KBLTYP
      COMMON/ZZZ31/NSTAG,MVORT,NSPIRAL,SPIRAL
      DIMENSION XK(3,NNODE),NODE(4,NELEM)
      DIMENSION PC(3,NELEM),P1(3,NELEM),P2(3,NELEM),P3(3,NELEM)
      REAL LSHAFT,LSHANK
C
      ALFAR=ALFA*3.14159/180.
      SINALF=SIN(ALFAR)
      COSALF=COS(ALFAR)
      BETA=SQRT(ABS(1.-UMACH*UMACH))
C
      BET=ABETA*3.14159/180.
      SINBET=SIN(BET)
      COSBET=COS(BET)
C
      DO 100 INODE=1,NNODE
      XK1=XK(1,INODE)
      XK3=XK(3,INODE)
      XK(1,INODE)=(XK1*COSALF+XK3*SINALF)/BETA
      XK(3,INODE)=-XK1*SINALF+XK3*COSALF
      WRITE(6,61)INODE,XK1,XK3
   61 FORMAT(10X,*INODE=*,I5,2X,*XK1=*,E16.6,*XK3=*,E16.6)
  100 CONTINUE
      DO 101 INODE=1,NNODE
      XK1=XK(1,INODE)
```

```
      XK2=XK(2,INODE)
      XK(1,INODE)=XK1*COSBET+XK2*SINBET
      XK(2,INODE)=-XK1*SINBET+XK2*COSBET
  101 CONTINUE
      DO 200 IELEM=1,NELEM
      DO 199 K=1,3
      YPP=XK(K,NODE(1,IELEM))
      YPM=XK(K,NODE(2,IELEM))
      YMP=XK(K,NODE(3,IELEM))
      YMM=XK(K,NODE(4,IELEM))
      PC(K,IELEM)=(YPP+YPM+YMP+YMM)/4.
      P1(K,IELEM)=(YPP+YPM-YMP-YMM)/4.
      P2(K,IELEM)=(YPP-YPM+YMP-YMM)/4.
      P3(K,IELEM)=(YPP-YPM-YMP+YMM)/4.
C
199   CONTINUE
200   CONTINUE
C
      WRITE(6,60)
   60 FORMAT(10X,*--- END OF VEC.123 ---*)
      RETURN
      END
```

```
C       ########## SUBROUTINE PRINTA ##############################################
C
      SUBROUTINE PRINTA(NELEM,NXYMP,XK,NNODE,PC,NOFCT,NODE,NPRINT)
      COMMON/ZZZ1/NX(34),NY(34),NXY(34),KSYMMY,KSYMMZ,NSYMMY,NSYMMZ
      COMMON/ZZZ2/NSFX,NSBODY,NS,NT(34),ISFACE(34),KNORML(34),KWAKES(34)
      COMMON/ZZZ3/NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,NSHAFT,NHUB,NSHANK,
     1 NBLADE
      COMMON/ZZZ4/UMACH,OMEGA,ALFA,ABETA
      COMMON/ZZZ5/XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      COMMON/ZZZ6/XNOSE,XBD1,XBD2,XTAIL
      COMMON/ZZZ7/YNOSE,YBD1,YBD2,YTAIL
      COMMON/ZZZ8/ZNOSE,ZBD1,ZBD2,ZTAIL
      COMMON/ZZZ9/RYBD1,RZBD1,RYBD2,RZBD2
      COMMON/ZZZ10/RSHAFT,LSHAFT,RSHANK,LSHANK
      COMMON/ZZZ11/XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
      COMMON/ZZZ12/RROTOR,BCHORD,TAUBL,ALFAR
      COMMON/ZZZ13/THET75,THET1C,THET1S,CONING,AZIMUTH
      COMMON/ZZZ14/KBLADE,TANLEB,TANTEB,XBLE,XBTE,KROTORS(34)
      COMMON/ZZZ15/VSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAU,ZVTAIL
      COMMON/ZZZ16/NWAKPY,NWAKHB,NWAKSK,NWAKBL
      COMMON/ZZZ17/WAKLPY,WAKLHB,WAKLSK,WAKLBL
      COMMON/ZZZ18/WANGPY,WANGHB,WANGSK,WANGBL
      COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
      COMMON/ZZZ20/PI
      COMMON/ZZZ21/KPY1,KPY2
      COMMON/ZZZ22/KNSELE,KNSSHP,KNSTYP
      COMMON/ZZZ23/KBDELE,KBDSHP,KBDTYP
      COMMON/ZZZ24/KTNELE,KTNSHP,KTNTYP
      COMMON/ZZZ25/KPYELE,KPYSHP,KPYTYP
      COMMON/ZZZ26/KVTELE,KVTSHP,KVTTYP
      COMMON/ZZZ27/KSHELE,KSHSHP,KSHTYP
      COMMON/ZZZ28/KHBELE,KHBSHP,KHBTYP
      COMMON/ZZZ29/KSKELE,KSKSHP,KSKTYP
      COMMON/ZZZ30/KBLELE,KBLSHP,KBLTYP
      COMMON/ZZZ31/NSTAG,NVORT,NSPIRAL,SPIRAL
      DIMENSION PC(3,NELEM),XK(3,NNODE),NOFCT(NXYMP,34),NODE(4,NELEM)
      REAL LSHAFT,LSHANK
C
      GO TO (1,2,3,4),NPRINT
    1 CONTINUE
      WRITE(NWRITE,110)
  110 FORMAT(///2X,*SPECIFICATIONS OF THE PROBLEM */)
      DO 112 II=1,NS
      IF(NXY(II).EQ.0)GO TO 112
      WRITE(NWRITE,113)ISFACE(II)
      WRITE(NWRITE,114)NX(II),NY(II)
  112 CONTINUE
  113 FORMAT(//2X,*FOR PART *,I3)
      WRITE(NWRITE,115)NELEM,KSYMMY,KSYMMZ,REFLEN,SPAN,TAU,
     1ALFA,ALFABC,UMACH,IZZZ
  114 FORMAT(2X,*NX=*,I2,/2X,*NY=*,I2/)
  115 FORMAT(//2X,*NELEM=*,I3//2X,*KSYMMY=*,I2/2X,*KSYMMZ=*,I2//
     1 2X,*REFERENCE LENGTH =*,F6.2/2X,*SPAN =*,F6.2/
     1 2X,*WING THICKNESS=*,F3.5//2X,*ALFA = *,F7.3/2X,*ALFABC =*,F7.3//
     1 2X,*MACH NUMBER =*,F7.3//2X,*IZZZ=*,I5//)
      WRITE(NWRITE,116)TANGLE,TANGTE,CHORD,R
  116 FORMAT(2X,*TANGLE=*,F6.2/2X,*TANGTE=*,F6.2//2X,*CHORD =*,F6.2
```

```
      1 //2X,*RADIUS =*,F6.2)
        RETURN
2       CONTINUE
        WRITE(NWRITE,222)
    222 FORMAT(//4X,*NODE=*,4X,*X*,10X,*Y*,10X,*Z*//)
        DO 2210 INODE=1,NNODE
2210    WRITE(NWRITE,221)INODE,(XK(K,INODE),K=1,3)
221     FORMAT(4X,I4,3(1X,F10.5))
220     CONTINUE
        RETURN
3       CONTINUE
        WRITE(NWRITE,340)
    340 FORMAT(////1X,*ELEM=*,4X,*XPC*,7X,*YPC*,7X,*ZPC*)
        DO 344 I=1,NELEM
344     WRITE(NWRITE,345)I,(PC(K,I),K=1,3)
345     FORMAT(1X,I3,12F10.5)
        RETURN
4       CONTINUE
        WRITE(NWRITE,41)
     41 FORMAT(//5X,*NODAL NUMBERING FOR SURFACES*//)
        DO 44 IS=1,NS
        NXP=NX(IS)+1
        NYP=NY(IS)+1
        NXYP=NXP*NYP
        WRITE(NWRITE,46)ISFACE(IS)
        DO 44 IX=1,NXP
        WRITE(NWRITE,45)(NOFCT(IXY,IS),IXY=IX,NXYP,NXP)
44      CONTINUE
45      FORMAT(11I6)
     46 FORMAT(/5X,*FOR SURFACE *,I5/)
        WRITE(NWRITE,47)
     47 FORMAT(//5X,*NODAL NUMBERING FOR ELEMENTS*//)
        WRITE(NWRITE,49)
        DO 48 IELEM=1,NELEM
48      WRITE(NWRITE,45)IELEM,(NODE(ICORNR,IELEM),ICORNR=1,4)
     49 FORMAT(//2X,*ELEM*,4X,*++*,4X,*+-*,4X,*-+*,4X,*--*/)
        RETURN
        END
```

```
C
C       ********** SUBROUTINE DEBUG  ****************************************
C
      SUBROUTINE DEBUG(K)
      COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
      WRITE(NWRITE,1)K
    1 FORMAT(/2X,*   ERROR CODE = *,I6/)
      RETURN
      END
```

```
C
C     ********** SUBROUTINE PRINTB ************************************
C
C
      SUBROUTINE PRINTB(NELEM,NESQ,AA,SOURCE,NPRINT)
      COMMON/ZZZ1/NX(34),NY(34),NXY(34),KSYMMY,KSYMMZ,NSYMMY,NSYMMZ
      COMMON/ZZZ2/NSFX,NSBODY,NS,NT(34),ISFACE(34),KNORML(34),KWAKES(34)
      COMMON/ZZZ3/NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,NSHAFT,NHUB,NSHANK,
     1 NBLADE
      COMMON/ZZZ4/UMACH,OMEGA,ALFA,ABETA
      COMMON/ZZZ5/XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      COMMON/ZZZ6/XNOSE,XBD1,XBD2,XTAIL
      COMMON/ZZZ7/YNOSE,YBD1,YBD2,YTAIL
      COMMON/ZZZ8/ZNOSE,ZBD1,ZBD2,ZTAIL
      COMMON/ZZZ9/RYBD1,RZBD1,RYBD2,RZBD2
      COMMON/ZZZ10/RSHAFT,LSHAFT,RSHANK,LSHANK
      COMMON/ZZZ11/XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
      COMMON/ZZZ12/RROTOR,RCHORD,TAUBL,ALFA0
      COMMON/ZZZ13/THET75,THET1C,THET1S,CONING,AZIMUTH
      COMMON/ZZZ14/KBLADE,TANLEB,TANTEB,XBLE,XBTE,KROTORS(34)
      COMMON/ZZZ15/VSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAU,ZVTAIL
      COMMON/ZZZ16/NWAKPY,NWAK4B,NWAKSK,NWAKBL
      COMMON/ZZZ17/WAKLPY,WAKL4B,WAKLSK,WAKLBL
      COMMON/ZZZ18/WANGPY,WANG4B,WANGSK,WANGBL
      COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
      COMMON/ZZZ20/PI
      COMMON/ZZZ21/KPY1,KPY2
      COMMON/ZZZ22/KNSELE,KNSSHP,KNSTYP
      COMMON/ZZZ23/KBDELE,KBDSHP,KBDTYP
      COMMON/ZZZ24/KTNELE,KTNSHP,KTNTYP
      COMMON/ZZZ25/KPYELE,KPYSHP,KPYTYP
      COMMON/ZZZ26/KVTELE,KVTSHP,KVTTYP
      COMMON/ZZZ27/KSHELE,KSHSHP,KSHTYP
      COMMON/ZZZ28/KHBELE,KHBSHP,KHBTYP
      COMMON/ZZZ29/KSKELE,KSKSHP,KSKTYP
      COMMON/ZZZ30/KBLELE,KBLSHP,KBLTYP
      COMMON/ZZZ31/NSTAG,NVORT,NSPIRAL,SPIRAL
C
      DIMENSION SOURCE(NELEM),AA(NESQ)
      DIMENSION ABSVAL(100),FMEAN(100)
      REAL LSHAFT,LSHANK
      NY4=4*(NY(1)-1)
      GO TO(1,2,3,4,5),NPRINT
    1 CONTINUE
      WRITE(NWRITE,110)
  110 FORMAT(///2X,*DISTRIBUTION OF AA(I,J)*/)
      DO 11 I=1,NELEM
      WRITE(NWRITE,111)I
      N1=I
      N2=NELEM*NELEM
  111 FORMAT(2X,*INDEX =*,I2)
      WRITE(NWRITE,112)(AA(K),K=N1,N2,NELEM)
  112 FORMAT(1X,8E15.6)
   11 CONTINUE
      RETURN
    2 CONTINUE
      WRITE(NWRITE,221)
```

```
  221 FORMAT(///2X,*THE DISTR 3UTION OF SOURCE*)
225   CONTINUE
      NSBTOT=0
      DO 229 IS=1,NS
      WRITE(NWRITE,223)ISFACE(IS)
  223 FORMAT(//5X,*FOR SUBSURFACE*I3)
      IND=NSBTOT
      NSBTOT=NSBTOT+NX(IS)*NY(IS)
      IFIN=NSBTOT
      NXX=NX(IS)
      DO 226 IX=1,NXX
      WRITE(NWRITE,228)
      IF(NPRINT.GE.5.AND.(IX.EQ.NXX))GO TO 226
      IND=IND+1
      WRITE(NWRITE,227)(SOURC (KK),KK=IND,IFIN,NXX)
226   CONTINUE
227   FORMAT(1X,8E15.5)
228   FORMAT(/)
229   CONTINUE
      RETURN
3     CONTINUE
      WRITE(NWRITE,330)
  330 FORMAT(///2X,*THE DISTRIBUTION OF THE VELOCITY POTENTIAL*)
      GO TO 225
4     CONTINUE
      WRITE(NWRITE,440)
  440 FORMAT(///2X,*THE DISTRIBUTION OF CP*)
      GO TO 225
5     CONTINUE
      RETURN
      END
```

```
C
C
C
      SUBROUTINE SOLUTN(NELEM,NESQ,AA,SOURCE)
C
      COMMON/ZZZ1/NX(34),NY(34),NXY(34),KSYMMY,KSYMMZ,NSYMMY,NSYMMZ
      COMMON/ZZZ2/NSFX,NSBODY,NS,NT(34),ISFACE(34),KNORML(34),KWAKES(34)
      COMMON/ZZZ3/NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,NSHAFT,NHUB,NSHANK,
     1 NBLADE
      COMMON/ZZZ4/UMACH,OMEGA,ALFA,ABETA
      COMMON/ZZZ5/XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      COMMON/ZZZ6/XNOSE,XBD1,XBD2,XTAIL
      COMMON/ZZZ7/YNOSE,YBD1,YBD2,YTAIL
      COMMON/ZZZ8/ZNOSE,ZBD1,ZBD2,ZTAIL
      COMMON/ZZZ9/RYBD1,RZBD1,RYBD2,RZBD2
      COMMON/ZZZ10/RSHAFT,LSHAFT,RSHANK,LSHANK
      COMMON/ZZZ11/XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
      COMMON/ZZZ12/RROTOR,RCHORD,TAUBL,ALFA2
      COMMON/ZZZ13/THET75,THET1C,THET1S,CONING,AZIMUTH
      COMMON/ZZZ14/KBLADE,TANLEB,TANTEB,XBLE,XBTE,KROTORS(34)
      COMMON/ZZZ15/VSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAU,ZVTAIL
      COMMON/ZZZ16/NWAKPY,NWAKHB,NWAKSK,NWAKBL
      COMMON/ZZZ17/WAKLPY,WAKLHB,WAKLSK,WAKLBL
      COMMON/ZZZ18/WANGPY,WANGHB,WANGSK,WANGBL
      COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
      COMMON/ZZZ20/PI
      COMMON/ZZZ21/KPY1,KPY2
      COMMON/ZZZ22/KNSELE,KNSSHP,KNSTYP
      COMMON/ZZZ23/KBDELE,KBDSHP,KBDTYP
      COMMON/ZZZ24/KTNELE,KTNSHP,KTNTYP
      COMMON/ZZZ25/KPYELE,KPYSHP,KPYTYP
      COMMON/ZZZ26/KVTELE,KVTSHP,KVTTYP
      COMMON/ZZZ27/KSHELE,KSHSHP,KSHTYP
      COMMON/ZZZ28/KHBELE,KHBSHP,KHBTYP
      COMMON/ZZZ29/KSKELE,KSKSHP,KSKTYP
      COMMON/ZZZ30/KBLELE,KBLSHP,KBLTYP
      COMMON/ZZZ31/NSTAG,NVORT,NSPIRAL,SPIRAL
      DIMENSION AA(NESQ),SOURCE(NELEM)
      REAL LSHAFT,LSHANK
C
      IF(KPRINT(5).EQ.1)CALL PRINTB(NELEM,NESQ,AA,SOURCE,1)
      IF(KPRINT(6).EQ.1)CALL PRINTB(NELEM,NESQ,AA,SOURCE,2)
      TOL=0.001
      CALL CCGELG(SOURCE,AA,NELEM,1,TOL,IER)
C
      IF(IER.NE.0)WRITE(NWRITE,101)IER
C     IF(IER.NE.0)CALL DEBUG(L001)
  101 FORMAT(////2X,*   IER = *,I4///)
      IF(KPRINT(7).EQ.1)CALL PRINTB(NELEM,NESQ,AA,SOURCE,3)
      RETURN
      END
```

```
C
      SUBROUTINE C[illegible]GELG(R,A,M,N,EPS,IER)
C
C
C
C
      DIMENSION A(1),R(1)
      IF(M)23,23,1
C
C     SEARCH FOR GREATEST ELEMENT IN MATRIX A
    1 IER=0
      PIV=0.
      MM=M*M
      NM=N*M
      DO 3 L=1,MM
      TBB= ABS(A(L))
      IF(TBB-PIV)3,3,2
    2 PIV=TBB
      I=L
    3 CONTINUE
      TOL=EPS*PIV
C     A(I) IS PIVOT ELEMENT. PIV CONTAINS THE ABSOLUTE VALUE OF A(I).
C
C
C     START ELIMINATION LOOP
      LST=1
      DO 17 K=1,M
C
C     TEST ON SINGULARITY
      IF(PIV)23,23,4
    4 IF(IER)7,5,7
    5 IF(PIV-TOL)6,6,7
    6 IER=K-1
    7 PIVI=1./A(I)
      J=(I-1)/M
      I=I-J*M-K
      J=J+1-K
C     I+K IS ROW-INDEX, J+K COLUMN-INDEX OF PIVOT ELEMENT
C
C     PIVOT ROW REDUCTION AND ROW INTERCHANGE IN RIGHT HAND SIDE R
      DO 8 L=K,NM,M
      LL=L+I
      TB=PIVI*R(LL)
      R(LL)=R(L)
    8 R(L)=TB
C
C     IS ELIMINATION TERMINATED
      IF(K-M)9,18,18
C
C     COLUMN INTERCHANGE IN MATRIX A
    9 LEND=LST+M-K
      IF(J)12,12,10
   10 II=J*M
      DO 11 L=LST,LEND
      TB=A(L)
      LL=L+II
      A(L)=A(LL)
```

```
   11 A(LL)=TB
C
C     ROW INTERCHANGE AND PIVOT ROW REDUCTION IN MATRIX A
   12 DO 13 L=LST,NM,M
      LL=L+I
      TB=PIVI*A(LL)
      A(LL)=A(L)
   13 A(L)=TB
C
C     SAVE COLUMN INTERCHANGE INFORMATION
      A(LST)=J
C
C     ELEMENT REDUCTION AND NEXT PIVOT SEARCH
      PIV=0.
      LST=LST+1
      J=0
      DO 17 II=LST,LEND
      PIVI=-A(II)
      IST=II+M
      J=J+1
      DO 15 L=IST,NM,M
      LL=L-J
      A(L)=A(L)+PIVI*A(LL)
      TBB= ABS(A(L))
      IF(TBB-PIV)15,15,14
   14 PIV=TBB
      I=L
   15 CONTINUE
      DO 16 L=K,NM,M
      LL=L+J
   16 R(LL)=R(LL)+PIVI*R(L)
   17 LST=LST+M
C     END OF ELIMINATION LOOP
C
C
C     BACK SUBSTITUTION AND BACK INTERCHANGE
   18 IF(M-1)23,22,19
   19 IST=MM+M
      LST=M+1
      DO 21 I=2,M
      II=LST-I
      IST=IST-LST
      L=IST-M
      L=A(L)+.5
      DO 21 J=II,NM,M
      TB=R(J)
      LL=J
      DO 20 K=IST,MM,M
      LL=LL+1
   20 TB=TB-A(K)*R(LL)
      K=J+L
      R(J)=R(K)
   21 R(K)=TB
   22 RETURN
C
C
C     ERROR RETURN
   23 IER=-1
      RETURN
      END
```

```
C       ********** SUBROUTINE COEFF ****************************************
C
C       ******************** DATE CREATED : APRIL 10 ,1975 ************
C
        SUBROUTINE COEFF(NELEM,PC,NNODE,XK,NODE,KWAKE,NESQ,AA,SOURCE,
       1 BC,KROTOR,ICHECK)
C
C        HIS SUBPROGRAM IS TO CALCULATE
C       AND            FOR                             FLOW
C
C
        COMMON/ZZZ1/NX(34),NY(34),NXY(34),KSYMMY,KSYMMZ,NSYMMY,NSYMMZ
        COMMON/ZZZ2/NSFX,NSBODY,NS,NT(34),ISFACE(34),KNORML(34),KWAKES(34)
        COMMON/ZZZ3/NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,NSHAFT,NHUB,NSHANK,
       1 NBLADE
        COMMON/ZZZ4/IMACH,OMEGA,ALFA,ABETA
        COMMON/ZZZ5/XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
        COMMON/ZZZ6/XNOSE,XBD1,XBD2,XTAIL
        COMMON/ZZZ7/YNOSE,YBD1,YBD2,YTAIL
        COMMON/ZZZ8/ZNOSE,ZBD1,ZBD2,ZTAIL
        COMMON/ZZZ9/RYBD1,RZBD1,RYBD2,RZBD2
        COMMON/ZZZ10/RSHAFT,LSHAFT,RSHANK,LSHANK
        COMMON/ZZZ11/XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
        COMMON/ZZZ12/RROTOR,BCHORD,TAUBL,ALFAR
        COMMON/ZZZ13/THET75,THET1C,THET1S,CONING,AZIMUTH
        COMMON/ZZZ14/KBLADE,TANLEB,TANTEB,XBLE,XBTE,KROTORS(34)
        COMMON/ZZZ15/VSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAU,ZVTAIL
        COMMON/ZZZ16/NWAKPY,NWAKHB,NWAKSK,NWAKBL
        COMMON/ZZZ17/WAKLPY,WAKLHB,WAKLSK,WAKLBL
        COMMON/ZZZ18/WANGPY,WANGHB,WANGSK,WANGBL
        COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
        COMMON/ZZZ20/PI
        COMMON/ZZZ21/KPY1,KPY2
        COMMON/ZZZ22/KNSELE,KNSSHP,KNSTYP
        COMMON/ZZZ23/KBDELE,KBDSHP,KBDTYP
        COMMON/ZZZ24/KTNELE,KTNSHP,KTNTYP
        COMMON/ZZZ25/KPYELE,KPYSHP,KPYTYP
        COMMON/ZZZ26/KVTELE,KVTSHP,KVTTYP
        COMMON/ZZZ27/KSHELE,KSHSHP,KSHTYP
        COMMON/ZZZ28/KHBELE,KHBSHP,KHBTYP
        COMMON/ZZZ29/KSKELE,KSKSHP,KSKTYP
        COMMON/ZZZ30/KBLELE,KBLSHP,KBLTYP
        COMMON/ZZZ31/NSTAG,NVORT,NSPIRAL,SPIRAL
        COMMON/ZZZ32/CSTAG,CVORT
        COMMON/ZZZ33/UWAKE
        DIMENSION KROTOR(NELEM)
        DIMENSION QV(3)
        DIMENSION XK(3,NNODE),NODE(4,NELEM),
       1PC(3,NELEM),SOURCE(NELEM),KWAKE(NELEM),AA(NESQ)
        DIMENSION A1(3,2),A2(3,2),A1A1(2),A2A2(2),QCRA1(3),QCRA2(3)
        DIMENSION A1V(3),A2V(3),VNORM(3),UN(3),SN(3),SNUN(3),A1A2(2,2)
        DIMENSION PZ(3),Q(3,4),QMCRA1(3,2),QMCRA2(3,2),AA1(3,2),AA2(3,2)
        DIMENSION VMM(3),VOD(3),VMD(3),VTEPZ(3),VTEMZ(3),SIGNPT(3)
        DIMENSION AVA1(3),AVA2(3),A1CRA2(4),QM(3,4)
        DIMENSION WPP(3),WPM(3),WMP(3),WMM(3),WPC(3)
        DIMENSION BC(NELEM        )
        DIMENSION VPP(3),VPM(3),VMP(3),VMM(3)
```

```
      DIMENSION PCJ(3)
      REAL LSHAFT,LSHANK
C
      DOTPRD(X1,Y1,Z1,X2,Y2,Z2)=X1*X2+Y1*Y2+Z1*Z2
C
      PRDMIX(XX1,YY1,ZZ1,XX2,YY2,ZZ2,XX3,YY3,ZZ3)=(YY2*ZZ3-YY3*ZZ2)*XX1
     1                       -(XX2*ZZ3-XX3*ZZ2)*YY1+(XX2*YY3-XX3*YY2)*ZZ1
      XPROX(DX,DY,DZ,EX,EY,EZ)=DY*EZ-EY*DZ
      XPROY(DX,DY,DZ,EX,EY,EZ)=DZ*EX-EZ*DX
      XPROZ(DX,DY,DZ,EX,EY,EZ)=DX*EY-EX*DY
C
      IF(UMACH.GT.1.)CALL DEBUG(400)
      BETA=SQRT(1.-UMACH**2)
C
C
C
C
      SIGMPT(1)=1.0
C
      CONSI=90.5/3.14159
C
C
      KOUNT=0
      DO 180 J=1,NELEM
C
      KSPIRAL=1
      LSPIRAL=1
      IF(ICHECK.EQ.4) KSPIRAL=NSPIRAL
      IF(ICHECK.EQ.4) LSPIRAL=NSPIRAL
      DO 180 ISP=1,KSPIRAL
      DO 180 NSP=1,LSPIRAL
C
      GO TO (100,200,300,400),ICHECK
C
  100 CONTINUE
C
      DO 94 K=1,3
      YPP(K)=XK(K,NODE(1,J))
      YPM(K)=XK(K,NODE(2,J))
      YMP(K)=XK(K,NODE(3,J))
      YMM(K)=XK(K,NODE(4,J))
      PCJ(K)=PC(K,J)
 94   CONTINUE
      GO TO 500
  200 CONTINUE
C     NSTAG=1
      IF(KOUNT.EQ.1) RETURN
      READ(NREAD,201)  (YPP(K),K=1,3)
      WRITE(NWRITE,202)(YPP(K),K=1,3)
      READ(NREAD,201)  (YPM(K),K=1,3)
      WRITE(NWRITE,202)(YPM(K),K=1,3)
      READ(NREAD,201)  (YMP(K),K=1,3)
      WRITE(NWRITE,202)(YMP(K),K=1,3)
      READ(NREAD,201)  (YMM(K),K=1,3)
      WRITE(NWRITE,202)(YMM(K),K=1,3)
      DO 205 K=1,3
  205 PCJ(K)=(YPP(K)+YPM(K)+YMP(K)+YMM(K))/4.
```

```
      KOUNT=1
      GO TO 500
  300 CONTINUE
C     NVORT=1
      IF(KOUNT.EQ.1)RETURN
      READ(NREAD,201)   (YPP(K),K=1,3)
      WRITE(NWRITE,202)(YPP(K),K=1,3)
      READ(NREAD,201)   (YPM(K),K=1,3)
      WRITE(NWRITE,202)(YPM(K),K=1,3)
      READ(NREAD,201)   (YMP(K),K=1,3)
      WRITE(NWRITE,202)(YMP(K),K=1,3)
      READ(NREAD,201)   (YMM(K),K=1,3)
      WRITE(NWRITE,202)(YMM(K ,K=1,3)
      DO 305 K=1,3
  305 PCJ(K)=(YPP(K)+YPM(K)+YMP(K)+YMM(K))/4.
      KOUNT=1
  201 FORMAT(    10F8.3)
  202 FORMAT(1X,10F8.3)
      GO TO 500
  400 CONTINUE
C     NSPIRAL=1
      IF(KWAKE(J).EQ.0) GO TO 100
      IF(KROTOR(J).EQ.0)GO TO 100
      DO 494 K=1,3
      YPP(K)=XK(K,NODE(1,J))
      YPM(K)=XK(K,NODE(2,J))
      YMP(K)=XK(K,NODE(3,J))
      YMM(K)=XK(K,NODE(4,J))
  494 CONTINUE
C
      RATIO=UWAKE/OMEGA
      RATIO=RATIO*50./(2.*PI)
      RATIO=-1.*RATIO
      FACTOR=2.*PI/NSPIRAL
C     DO 100 ISP=1,ISPIRAL
C     DO 100 NSP=1,NSPIRAL
      IWAKE=NSP+(ISP-1)*NSPIRAL
C
      THETA1=(IWAKE-1)*FACTOR
      THETA2= IWAKE    *FACTOR
C
      SIN1=SIN(THETA1)
      COS1=COS(THETA1)
C
      SIN2=SIN(THETA2)
      COS2=COS(THETA2)
C
      XPP2= YPP(1)*COS2+YPP(2)*SIN2
      YPP2=-YPP(1)*SIN2+YPP(2)*COS2
C
      XMP1= YPP(1)*COS1+YPP(2)*SIN1
      YMP1=-YPP(1)*SIN1+YPP(2)*COS1
C
      XMM1= YPM(1)*COS1+YPM(2)*SIN1
      YMM1=-YPM(1)*SIN1+YPM(2)*COS1
C
      XPM2= YPM(1)*COS2+YPM(2)*SIN2
```

```
      YPM2=-YPM(1)*SIN2+YPM(2)*COS2
C
      RPP2=SQRT(XPP2*XPP2+YPP2*YPP2)
      RMP1=SQRT(XMP1*XMP1+YMP1*YMP1)
      RMM1=SQRT(XMM1*XMM1+YMM1*YMM1)
      RPM2=SQRT(XPM2*XPM2+YPM2*YPM2)
C
      IF(MSP.GT.1) GO TO 503
C
      ZP=0.0
      ZPP2=ZP+RATIO*THETA2*RPP2/RROTOR
      ZMP1=ZP+RATIO*THETA1*RMP1/RROTOR
       ZMM1=ZP+RATIO*THETA1*RMM1/RROTOR
      ZPM2=ZP+RATIO*THETA2*RPM2/RROTOR
      GO TO 504
  503 CONTINUE
      ZPP2=ZP+RATIO*(THETA2-FACTOR)+RATIO*FACTOR*RPP2/RROTOR
      ZMP1=ZP+RATIO*(THETA1-FACTOR)+RATIO*FACTOR*RMP1/RROTOR
      ZMM1=ZP+RATIO*(THETA1-FACTOR)+RATIO*FACTOR*RMM1/RROTOR
      ZPM2=ZP+RATIO*(THETA2-FACTOR)+RATIO*FACTOR*RPM2/RROTOR
  504 CONTINUE
C
      YPP(1)=XPP2
      YPP(2)=YPP2
      YPP(3)=ZPP2
C
      YPM(1)=XPM2
      YPM(2)=YPM2
      YPM(3)=ZPM2
C
      YMP(1)=XMP1
      YMP(2)=YMP1
      YMP(3)=ZMP1
C
      YMM(1)=XMM1
      YMM(2)=YMM1
      YMM(3)=ZMM1
C
      IF(ZPP2.LT.(ZBD1+RZBD1+ZPYL))GO TO 180
      IF(ZPM2.LT.(ZBD1+RZBD1+ZPYL)) GO TO 180
C
      DO 505 K=1,3
  505 PCJ(K)=(YPP(K)+YPM(K)+YMP(K)+YMM(K))/4.
C
C
  180 CONTINUE
C
      DO 1002 K=1,3
      AA1(K,1)=0.5*(YPP(K)-YMP(K))
      AA1(K,2)=0.5*(YPM(K)-YMM(K))
      AA2(K,1)=0.5*(YPP(K)-YPM(K))
      AA2(K,2)=0.5*(YMP(K)-YMM(K))
      A1(K,1)=AA1(K,1)
      A1(K,2)=AA1(K,2)
      A2(K,1)=AA2(K,1)
      A2(K,2)=AA2(K,2)
 1002 CONTINUE
```

```
      DO 1003 L=1,2
      A1A1(L)=DOTPRO(A1(1,L),A1(2,L),A1(3,L),A1(1,L),A1(2,L),A1(3,L))
 1003 A2A2(L)=DOTPRO(A2(1,L),A2(2,L),A2(3,L),A2(1,L),A2(2,L),A2(3,L))
C
      DO 1004 K=1,3
      IF(A1A1(1).EQ.0.)A1(K,1)=A1(K,2)
      IF(A1A1(2).EQ.0.)A1(K,2)=A1(K,1)
      IF(A2A2(1).EQ.0.)A2(K,1)=A2(K,2)
      IF(A2A2(2).EQ.0.)A2(K,2)=A2(K,1)
 1004 CONTINUE
C
      DO 1006 L=1,2
      A1A1(L)=DOTPRO(A1(1,L),A1(2,L),A1(3,L),A1(1,L),A1(2,L),A1(3,L))
 1006 A2A2(L)=DOTPRO(A2(1,L),A2(2,L),A2(3,L),A2(1,L),A2(2,L),A2(3,L))
C
      DO 1007 L=1,2
      DO 1007 M=1,2
 1007 A1A2(L,M)=DOTPRO(A1(1,L),A1(2,L),A1(3,L),A2(1,M),A2(2,M),A2(3,M))
C
      A1CRA2(1)=SQRT(A1A1(2)*A2A2(1)-A1A2(2,1)**2)
      A1CRA2(2)=SQRT(A1A1(1)*A2A2(1)-A1A2(1,1)**2)
      A1CRA2(3)=SQRT(A1A1(1)*A2A2(2)-A1A2(1,2)**2)
      A1CRA2(4)=SQRT(A1A1(2)*A2A2(2)-A1A2(2,2)**2)
C
      DO 1008 K=1,3
      AVA1(K)=0.5*(A1(K,1)+A1(K,2))
 1008 AVA2(K)=0.5*(A2(K,1)+A2(K,2))
C
      YNORM(1)=AVA1(2)*AVA2(3)-AVA1(3)*AVA2(2)
      YNORM(2)=AVA1(3)*AVA2(1)-AVA1(1)*AVA2(3)
      YNORM(3)=AVA1(1)*AVA2(2)-AVA1(2)*AVA2(1)
C
      SN(1)=YNORM(1)/BETA
      SN(2)=YNORM(2)
      SN(3)=YNORM(3)
      ASN=SQRT(SN(1)**2+SN(2)**2+SN(3)**2)
      AYN=SQRT(YNORM(1)**2+YNORM(2)**2+YNORM(3)**2)
      DO 1010 K=1,3
      UN(K)=YNORM(K)/AYN
      SNUN(K)=SN(K)/ASN
 1010 CONTINUE
C
C
      DO 170 I=1,NELEM
C
      DO 160 ISYMMY=1,NSYMMY
      DO 160 ISYMMZ=1,NSYMMZ
      SIGNPT(2)=3.-2*ISYMMY
      SIGNPT(3)=3.-2*ISYMMZ
C
      DO 1102 K=1,3
 1102 PZ(K)=PCJ(K)-PC(K,I)*SIGNPT(K)
      QDOTUN=DOTPRO(UN(1),UN(2),UN(3),PZ(1),PZ(2),PZ(3))
C
      DO 1110 K=1,3
      Q(K,1)=YPM(K)-PC(K,I)*SIGNPT(K)
      Q(K,2)=YPP(K)-PC(K,I)*SIGNPT(K)
```

```
      Q(K,3)=YMP(K)-PC(K,I)*SIGNPT(K)
      Q(K,4)=YMM(K)-PC(K,I)*SIGNPT(K)
1110  CONTINUE
      DO 1111 K=1,3
      QM(K,1)=0.5*(Q(K,1)+Q(K,2))
      QM(K,2)=0.5*(Q(K,2)+Q(K,3))
      QM(K,3)=0.5*(Q(K,3)+Q(K,4))
      QM(K,4)=0.5*(Q(K,4)+Q(K,1))
1111  CONTINUE
C
      DO 1112 K=1,3
      KP1=K+1
      KP2=K+2
      IF(KP1.GT.3)KP1=KP1-3
      IF(KP2.GT.3)KP2=KP2-3
      QMCRA1(K,1)=QM(KP1,2)*A1(KP2,1)-QM(KP2,2)*A1(KP1,1)
      QMCRA1(K,2)=QM(KP1,4)*A1(KP2,2)-QM(KP2,4)*A1(KP1,2)
      QMCRA2(K,1)=QM(KP1,1)*A2(KP2,1)-QM(KP2,1)*A2(KP1,1)
      QMCRA2(K,2)=QM(KP1,3)*A2(KP2,2)-QM(KP2,3)*A2(KP1,2)
1112  CONTINUE
C
      RC=SQRT(DOTPRO(PZ(1),PZ(2),PZ(3),PZ(1),PZ(2),PZ(3)))
C
      DO 155 ICORNR=1,4
      GO TO (5502,5504,5506,5508),ICORNR
5502  CONTINUE
      SIGN12=-1.
      ICSI=1
      IETA=2
      GO TO 5510
5504  CONTINUE
      SIGN12=+1.
      ICSI=1
      IETA=1
      GO TO 5510
5506  CONTINUE
      SIGN12=-1.
      ICSI=2
      IETA=1
      GO TO 5510
5508  CONTINUE
      SIGN12=+1.
      ICSI=2
      IETA=2
5510  CONTINUE
C
      DO 5520 K=1,3
      QV(K)=Q(K,ICORNR)
      A1V(K)=A1(K,IETA)
      A2V(K)=A2(K,ICSI)
      QCRA1(K)=QMCRA1(K,IETA)
      QCRA2(K)=QMCRA2(K,ICSI)
5520  CONTINUE
C
      QQ=SQRT(DOTPRO(QV(1),QV(2),QV(3),QV(1),QV(2),QV(3)))
C
      CALL LOG(ICORNR,QQ,QV,A1V,QCRA1,ALOG1,1)
```

```
C
      CALL LOG(ICORNR,QQ,QY,A2Y,QCRA2,ALOG2,2)
C
      TANP=0.
      IF(QDOTUN.EQ.0.)GO TO 5550
      HNUMER=-DOTPRO(QCRA1(1),QCRA1(2),QCRA1(3),QCRA2(1),QCRA2(2),
     1                                                    QCRA2(3))
      DENOM=QQ*QDOTUN*A1CRA2(ICORNR)
      IF(DENOM.NE.0.)TANP=ATAN2(HNUMER,DENOM)
 5550 CONTINUE
C
      COEFF1=DOTPRO(UN(1),UN(2),UN(3),QCRA1(1),QCRA1(2),QCRA1(3))
      COEFF2=DOTPRO(UN(1),UN(2),UN(3),QCRA2(1),QCRA2(2),QCRA2(3))
C
      SRCINT=-CONST*SIGN12*
     1      (-COEFF1*ALOG1+COEFF2*ALOG2-QDOTUN*TANP)
C
      GO TO (801,802,803,804),ICHECK
  801 CONC=1.0
      GO TO 850
  802 CONC=CSTAG
      GO TO 850
  803 CONC=CVORT
      GO TO 850
  804 CONC=1.0
  850 CONTINUE
      DBTINT=-CONST*SIGN12*TANP*CONC
C
      SGNINT=1.
C
      NNN=I+(J-1)*NELEM
C
      AA(NNN)=AA(NNN)-SGNINT*DBTINT
C
C
      IF(ICHECK.NE.1)GO TO 600
      UFREE=UMACH*1117.
      OMEGAX=0.
      OMEGAY=0.
      OMEGAZ=OMEGA*2.*PI/60.
      RX=PC(1,J)
      RY=PC(2,J)
      RZ=PC(3,J)
      BCX=XPROX(OMEGAX,OMEGAY,OMEGAZ,RX,RY,RZ)
      BCY=XPROY(OMEGAX,OMEGAY,OMEGAZ,RX,RY,RZ)
      BCZ=XPROZ(OMEGAX,OMEGAY,OMEGAZ,RX,RY,RZ)
      BCR=DOTPRO(BCX,BCY,BCZ,UN(1),UN(2),UN(3))
      IF(KROTOR(J).EQ.0) BCR=0.
      BCB=-1.*UFREE*UN(1)
      BC(J)=BCB+BCR
      SOURCE(I)=SOURCE(I)+SGNINT*SRCINT*        BC(J   )
  600 CONTINUE
C
C
150   CONTINUE
155   CONTINUE
160   CONTINUE
```

```
170   CONTINUE
180   CONTINUE
C
C
      RETURN
      END
```

```
C
C
      SUBROUTINE LOG(ICORNR,QQ,QV,AV,QCRAV,ALOG,ICOOR)
      DIMENSION QV(3)
      DIMENSION AV(3),QCRAV(3)
C
      DOTPRO(X1,Y1,Z1,X2,Y2,Z2)=X1*X2+Y1*Y2+Z1*Z2
C
      AVAV=DOTPRO(AV(1),AV(2),AV(3),AV(1),AV(2),AV(3))
      QQAV=DOTPRO(QV(1),QV(2),QV(3),AV(1),AV(2),AV(3))
      QXA=SQRT(DOTPRO(QCRAV(1),QCRAV(2),QCRAV(3),
     1                QCRAV(1),QCRAV(2),QCRAV(3)))
      ALOG=ASINH(QQAV/QXA)/SQRT(AVAV)
      RETURN
      END
```

```
C
C
      FUNCTION ATANP(HNUMER,DENOM)
      ADENOM=ABS(DENOM)
      ATANP=ATAN2(HNUMER,ADENOM)
      IF(DENOM.LT.0.)ATANP=-ATANP
      RETURN
      END
```

```
C
C
      SUBROUTINE AVERAG(SOURCE,SOR,PC,NELEM,NODE,NOFCT,NXYMF,NNODE,
     1 AVG)
      DIMENSION SOURCE(NELEM),SOR(NNODE),AVG(NNODE),PC(3,NELEM)
      DIMENSION NODE(4,NELEM),NOFCT(NXYMP,34)
      COMMON/ZZZ1/NX(34),NY(34),NXY(34),KSYMMY,KSYMMZ,NSYMMY,NSYMMZ
      COMMON/ZZZ2/NSEX,NSBODY,NS,NT(34),ISFACE(34),KNORML(34),KWAKES(34)
      COMMON/ZZZ3/NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,NSHAFT,NHUB,NSHANK,
     1 NBLADE
      COMMON/ZZZ4/UMACH,OMEGA ALFA,ABETA
      COMMON/ZZZ5/XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      COMMON/ZZZ6/XNOSE,XBD1,XBD2,XTAIL
      COMMON/ZZZ7/YNOSE,YBD1,YBD2,YTAIL
      COMMON/ZZZ8/ZNOSE,ZBD1,ZBD2,ZTAIL
      COMMON/ZZZ9/RYBD1,RZBD1,RYBD2,RZBD2
      COMMON/ZZZ10/RSHAFT,LSHAFT,RSHANK,LSHANK
      COMMON/ZZZ11/XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
      COMMON/ZZZ12/RROTOR,BCHORD,TAUBL,ALFAR
      COMMON/ZZZ13/THETZS,THET1C,THET1S,CONING,AZIMUTH
      COMMON/ZZZ14/KBLADE,TANLEB,TANTEB,XBLE,XBTE,KROTORS(34)
      COMMON/ZZZ15/YSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAU,ZVTAIL
      COMMON/ZZZ16/NWAKPY,NWAKHB,NWAKSK,NWAKBL
      COMMON/ZZZ17/WAKLPY,WAKLHB,WAKLSK,WAKLBL
      COMMON/ZZZ18/WANGPY,WANGHB,WANGSK,WANGBL
      COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
      COMMON/ZZZ20/PI
      COMMON/ZZZ21/KPY1,KPY2
      COMMON/ZZZ22/KNSELE,KNSSHP,KNSTYP
      COMMON/ZZZ23/KBDELE,KBDSHP,KBDTYP
      COMMON/ZZZ24/KTNELE,KTNSHP,KTNTYP
      COMMON/ZZZ25/KPYELE,KPYSHP,KPYTYP
      COMMON/ZZZ26/KVTELE,KVTSHP,KVTTYP
      COMMON/ZZZ27/KSHELE,KSHSHP,KSHTYP
      COMMON/ZZZ28/KHBELE,KHBSHP,KHBTYP
      COMMON/ZZZ29/KSKELE,KSKSHP,KSKTYP
      COMMON/ZZZ30/KBLELE,KBLSHP,KBLTYP
      COMMON/ZZZ31/NSTAG,NVORT,NSPIRAL,SPIRAL
      INTEGER PM,PP
      REAL LSHAFT,LSHANK
C
      DO 90 INODE=1,NNODE
      AVG(INODE)=0.
   90 SOR(INODE)= 0.
      DO 100 IELEM=1,NELEM
      PP=NODE(1,IELEM)
      PM=NODE(2,IELEM)
      MP=NODE(3,IELEM)
      MM=NODE(4,IELEM)
      SOR(PP)=SOR(PP)+SOURCE(IELEM)
      SOR(PM)=SOR(PM)+SOURCE(IELEM)
      SOR(MP)=SOR(MP)+SOURCE(IELEM)
      SOR(MM)=SOR(MM)+SOURCE(IELEM)
      AVG(PP)=AVG(PP)+1.
      AVG(PM)=AVG(PM)+1.
      AVG(MP)=AVG(MP)+1.
      AVG(MM)=AVG(MM)+1.
```

```
100   CONTINUE
      DO 110 INODE=1,NNODE
110   SOR(INODE)=SOR(INODE)/AVG(INODE)
199   CONTINUE
      SOR(1)=0.0
      SOR(2)=0.0
      RETURN
      END
```

```
C
      SUBROUTINE PHI(SOR,NNODE,NODE,PHIC,PHI1,PHI2,PHI3,NELEM)
      DIMENSION SOR(NNODE),PHIC(NELEM),PHI1(NELEM),PHI2(NELEM)
      DIMENSION PHI3(NELEM)
      DIMENSION NODE(4,NELEM)
      COMMON/ZZZ1/NX(34),NY(34),NXY(34),KSYMMY,KSYMMZ,NSYMMY,NSYMMZ
      COMMON/ZZZ2/NSFX,NSBODY,NS,NT(34),ISFACE(34),KNORML(34),KWAKES(34)
      COMMON/ZZZ3/NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,NSHAFT,NHUB,NSHANK,
     1 NBLADE
      COMMON/ZZZ4/UMACH,OMEGA,ALFA,ABETA
      COMMON/ZZZ5/XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      COMMON/ZZZ6/XNOSE,XBD1,XBD2,XTAIL
      COMMON/ZZZ7/YNOSE,YBD1,YBD2,YTAIL
      COMMON/ZZZ8/ZNOSE,ZBD1,ZBD2,ZTAIL
      COMMON/ZZZ9/RYBD1,RZBD1,RYBD2,RZBD2
      COMMON/ZZZ10/RSHAFT,LSHAFT,RSHANK,LSHANK
      COMMON/ZZZ11/XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
      COMMON/ZZZ12/RROTOR,BCHORD,TAUBL,ALFAB
      COMMON/ZZZ13/THET75,THET1C,THET1S,CONING,AZIMUTH
      COMMON/ZZZ14/KBLADE,TANLEB,TANTEB,XBLE,XBTE,KROTORS(34)
      COMMON/ZZZ15/VSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAU,ZVTAIL
      COMMON/ZZZ16/NWAKPY,NWAKHB,NWAKSK,NWAKBL
      COMMON/ZZZ17/WAKLPY,WAKLHB,WAKLSK,WAKLBL
      COMMON/ZZZ18/WANGPY,WANGHB,WANGSK,WANGBL
      COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
      COMMON/ZZZ20/PI
      COMMON/ZZZ21/KPY1,KPY2
      COMMON/ZZZ22/KNSELE,KNSSHP,KNSTYP
      COMMON/ZZZ23/KBDELE,KBDSHP,KBDTYP
      COMMON/ZZZ24/KINELE,KINSHP,KINTYP
      COMMON/ZZZ25/KPYELE,KPYSHP,KPYTYP
      COMMON/ZZZ26/KVTELE,KVTSHP,KVTTYP
      COMMON/ZZZ27/KSHELE,KSHSHP,KSHTYP
      COMMON/ZZZ28/KHBELE,KHBSHP,KHBTYP
      COMMON/ZZZ29/KSKELE,KSKSHP,KSKTYP
      COMMON/ZZZ30/KBLELE,KBLSHP,KBLTYP
      COMMON/ZZZ31/NSTAG,NVORT,NSPIRAL,SPIRAL
      INTEGER PM,PP
      REAL LSHAFT,LSHANK
      DO 701 IELEM=1,NELEM
      PP=NODE(1,IELEM)
      PM=NODE(2,IELEM)
      MP=NODE(3,IELEM)
      MM=NODE(4,IELEM)
      PHIC(IELEM)=(SOR(PP)+SOR(PM)+SOR(MP)+SOR(MM))/4.
      PHI1(IELEM)=(SOR(PP)+SOR(PM)-SOR(MP)-SOR(MM))/4.
      PHI2(IELEM)=(SOR(PP)-SOR(PM)+SOR(MP)-SOR(MM))/4.
      PHI3(IELEM)=(SOR(PP)-SOR(PM)-SOR(MP)+SOR(MM))/4.
701   CONTINUE
      WRITE(6,719)
  719 FORMAT(//6X,*ELEM*,9X,*PHIC*,11X,
     1*PHI1*9X,*PHI2*,9X,*PHI3*)
      DO 720 IELEM=1,NELEM
  720 WRITE(6,721)IELEM,PHIC(IELEM),PHI1(IELEM),PHI2(IELEM),PHI3(IELEM)
721   FORMAT(5X,I6,5X,6E15.5)
      RETURN
      END
```

```
C
      SUBROUTINE VELXYZ(VELX,VELY,VELZ,PHI1,PHI2,PHI3,PC,P1,P2,P3,
     1 NELEM)
      DIMENSION VELX(NELEM),PHI1(NELEM),PHI2(NELEM)
      DIMENSION PHI3(NELEM)
      DIMENSION VELY(NELEM),VELZ(NELEM)
      DIMENSION PC(3,NELEM),P1(3,NELEM),P2(3,NELEM),P3(3,NELEM)
      COMMON/ZZZ1/NX(34),NY(34),NXY(34),KSYMMY,KSYMMZ,NSYMMY,NSYMMZ
      COMMON/ZZZ2/NSFX,NSBODY,NS,NT(34),ISFACE(34),KNORML(34),KWAKES(34)
      COMMON/ZZZ3/NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,NSHAFT,NHUB,NSHANK,
     1 NBLADE
      COMMON/ZZZ4/UMACH,OMEGA,ALFA,ABETA
      COMMON/ZZZ5/XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      COMMON/ZZZ6/XNOSE,XBD1,XBD2,XTAIL
      COMMON/ZZZ7/YNOSE,YBD1,YBD2,YTAIL
      COMMON/ZZZ8/ZNOSE,ZBD1,ZBD2,ZTAIL
      COMMON/ZZZ9/RYBD1,RZBD1,RYBD2,RZBD2
      COMMON/ZZZ10/RSHAFT,LSHAFT,RSHANK,LSHANK
      COMMON/ZZZ11/XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
      COMMON/ZZZ12/RROTOR,BCHORD,TAUBL,ALFAB
      COMMON/ZZZ13/THET75,THET1C,THET1S,CONANG,AZIMUTH
      COMMON/ZZZ14/KBLADE,TANLEB,TANTEB,XBLE,XBTE,KROTORS(34)
      COMMON/ZZZ15/VSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAU,ZVTAIL
      COMMON/ZZZ16/NWAKPY,NWAKHB,NWAKSK,NWAKBL
      COMMON/ZZZ17/WAKLPY,WAKLHB,WAKLSK,WAKLBL
      COMMON/ZZZ18/WANGPY,WANGHB,WANGSK,WANGBL
      COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
      COMMON/ZZZ20/PI
      COMMON/ZZZ21/KPY1,KPY2
      COMMON/ZZZ22/KNSELE,KNSSHP,KNSTYP
      COMMON/ZZZ23/KBDELE,KBDSHP,KBDTYP
      COMMON/ZZZ24/KTNELE,KTNSHP,KTNTYP
      COMMON/ZZZ25/KPYELE,KPYSHP,KPYTYP
      COMMON/ZZZ26/KVTELE,KVTSHP,KVTTYP
      COMMON/ZZZ27/KSHELE,KSHSHP,KSHTYP
      COMMON/ZZZ28/KHBELE,KHBSHP,KHBTYP
      COMMON/ZZZ29/KSKELE,KSKSHP,KSKTYP
      COMMON/ZZZ30/KBLELE,KBLSHP,KBLTYP
      COMMON/ZZZ31/NSTAG,NVORT,NSPIRAL,SPIRAL
C
      DOTPRO(X1,X2,X3,Y1,Y2,Y3)=X1*Y1+X2*Y2+X3*Y3
      VECPRX(D1,D2,D3,E1,E2,E3)=D2*E3-D3*E2
      VECPRY(D1,D2,D3,E1,E2,E3)=D3*E1-D1*E3
      VECPRZ(D1,D2,D3,E1,E2,E3)=D1*E2-D2*E1
C
      DO 888 JELEM=1,NELEM
C
      A1XC=P1(1,JELEM)
      A1YC=P1(2,JELEM)
      A1ZC=P1(3,JELEM)
      A2XC=P2(1,JELEM)
      A2YC=P2(2,JELEM)
      A2ZC=P2(3,JELEM)
C
      A1XA2X=VECPRX(A1XC,A1YC,A1ZC,A2XC,A2YC,A2ZC)
      A1XA2Y=VECPRY(A1XC,A1YC,A1ZC,A2XC,A2YC,A2ZC)
      A1XA2Z=VECPRZ(A1XC,A1YC,A1ZC,A2XC,A2YC,A2ZC)
```

```
C
      A1XA2S=DOTPRO(A1XA2X,A1XA2Y,A1XA2Z,A1XA2X,A1XA2Y,A1XA2Z)
      A1XA2A=SQRT(A1XA2S)
C
      A1A1=DOTPRO(A1XC,A1YC,A1ZC,A1XC,A1YC,A1ZC)
      A1A2=DOTPRO(A1XC,A1YC,A1ZC,A2XC,A2YC,A2ZC)
      A2A2=DOTPRO(A2XC,A2YC,A2ZC,A2XC,A2YC,A2ZC)
C
      A11=A2A2/A1XA2S
      A12=-A1A2/A1XA2S
      A21=A12
      A22=A1A1/A1XA2S
C
      UNORMX=A1XA2X/A1XA2A
      UNORMY=A1XA2Y/A1XA2A
      UNORMZ=A1XA2Z/A1XA2A
C
      A1XU=A11*A1XC+A12*A2XC
      A1YU=A11*A1YC+A12*A2YC
      A1ZU=A11*A1ZC+A12*A2ZC
C
      A2XU=A21*A1XC+A22*A2XC
      A2YU=A21*A1YC+A22*A2YC
      A2ZU=A21*A1ZC+A22*A2ZC
C
      A3XU=UNORMX
      A3YU=UNORMY
      A3ZU=UNORMZ
C
      VELX(JELEM)=PHI1(JELEM)*A1XU+PHI2(JELEM)*A2XU
      VELY(JELEM)=PHI1(JELEM)*A1YU+PHI2(JELEM)*A2YU
      VELZ(JELEM)=PHI1(JELEM)*A1ZU+PHI2(JELEM)*A2ZU+PHI3(JELEM)*A3ZU
800   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE CPLINR(CP,VELX,VELY,VELZ,PHIC,NELEM,PC,KROTOR)
      DIMENSION CP(NELEM),VELX(NELEM),PHIC(NELEM)
      DIMENSION VELY(NELEM),VELZ(NELEM)
      DIMENSION PC(3,NELEM),KROTOR(NELEM)
      COMMON/ZZZ1/NX(34),NY(34),NXY(34),KSYMMY,KSYMMZ,NSYMMY,NSYMMZ
      COMMON/ZZZ2/NSEX,NSBODY,NS,NT(34),ISFACE(34),KNORML(34),KWAKES(34)
      COMMON/ZZZ3/NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,NSHAFT,NHUB,NSHANK,
     1 NBLADE
      COMMON/ZZZ4/UMACH,OMEGA,ALFA,ABETA
      COMMON/ZZZ5/XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      COMMON/ZZZ6/XNOSE,XBD1,XBD2,XTAIL
      COMMON/ZZZ7/YNOSE,YBD1,YBD2,YTAIL
      COMMON/ZZZ8/ZNOSE,ZBD1,ZBD2,ZTAIL
      COMMON/ZZZ9/RYBD1,RZBD1,RYBD2,RZBD2
      COMMON/ZZZ10/RSHAFT,LSHAFT,RSHANK,LSHANK
      COMMON/ZZZ11/XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
      COMMON/ZZZ12/RROTOR,BCHORD,TAUBL,ALFAB
      COMMON/ZZZ13/THETZS,THET1C,THET1S,CONING,AZIMUTH
      COMMON/ZZZ14/KBLADE,TANLEB,TANTEB,XBLE,XBTE,KROTORS(34)
      COMMON/ZZZ15/VSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAU,ZVTAIL
      COMMON/ZZZ16/NWAKPY,NWAKHB,NWAKSK,NWAKBL
      COMMON/ZZZ17/WAKLPY,WAKLHB,WAKLSK,WAKLBL
      COMMON/ZZZ18/WANGPY,WANGHB,WANGSK,WANGBL
      COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
      COMMON/ZZZ20/PI
      COMMON/ZZZ21/KPY1,KPY2
      COMMON/ZZZ22/KNSELE,KNSSHP,KNSTYP
      COMMON/ZZZ23/KBDELE,KBDSHP,KBDTYP
      COMMON/ZZZ24/KTNELE,KTNSHP,KTNTYP
      COMMON/ZZZ25/KPYELE,KPYSHP,KPYTYP
      COMMON/ZZZ26/KVTELE,KVTSHP,KVTTYP
      COMMON/ZZZ27/KSHELE,KSHSHP,KSHTYP
      COMMON/ZZZ28/KHBELE,KHBSHP,KHBTYP
      COMMON/ZZZ29/KSKELE,KSKSHP,KSKTYP
      COMMON/ZZZ30/KBLELE,KBLSHP,KBLTYP
      COMMON/ZZZ31/NSTAG,NVORT,NSPIRAL,SPIRAL
      DOTPRO(X1,Y1,Z1,X2,Y2,Z2)=X1*X2+Y1*Y2+Z1*Z2
      XPROX(DX,DY,DZ,EX,EY,EZ)=DY*EZ-EY*DZ
      XPROY(DX,DY,DZ,EX,EY,EZ)=DZ*EX-EZ*DX
      XPROZ(DX,DY,DZ,EX,EY,EZ)=DX*EY-EX*DY
      BETA2A=ABS(1.-UMACH**2)
      BETA=SQRT(BETA2A)
      UFREE=UMACH*1117
      OMEGAX=0.
      OMEGAY=0.
      OMEGAZ=OMEGA
      OMEGAZ=OMEGAZ*2.*PI/60.
      IF(UMACH.EQ.0) UFREE=OMEGA*2.*PI*RROTOR/60.
      DO 900 IELEM=1,NELEM
      RX=PC(1,IELEM)
      RY=PC(2,IELEM)
      RZ=PC(3,IELEM)
      VX=VELX(IELEM)
      VY=VELY(IELEM)
      VZ=VELZ(IELEM)
      CPB=(-2.*UFREE*VX-(VX*VX+VY*VY+VZ*VZ))/(UFREE*UFREE)
      CPB=(-2.*UFREE*VX   )/(UFREE*UFREE)
```

```
      CRX=XPROX(OMEGAX,OMEGAY,OMEGAZ,RX,RY,RZ)
      CRY=XPROY(OMEGAX,OMEGAY,OMEGAZ,RX,RY,RZ)
      CRZ=XPROZ(OMEGAX,OMEGAY,OMEGAZ,RX,RY,RZ)
      CPR=DOTPRO(CRX,CRY,CRZ,VX,VY,VZ)
      CPR=CPR*2./(UFREE*UFREE)
      IF(KROTOR(IELEM).EQ.0)CPR=0.
      CP(IELEM)=CPB+CPR
  300 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE FORCE(NNODE,XK,NELEM,NODE,CP)
      DIMENSION A1(3),A2(3),XK(3,NNODE),NODE(4,NELEM),RC(3),CP(NELEM)
      COMMON/ZZZ1/NX(34),NY(34),NXY(34),KSYMMY,KSYMMZ,NSYMMY,NSYMMZ
      COMMON/ZZZ2/NSEX,NSBODY,NS,NT(34),ISFACE(34),KNORML(34),KWAKES(34)
      COMMON/ZZZ3/NPYLON,NBODY1,NBODY2,NBODY3,NVTAIL,NSHAFT,NHUB,NSHANK,
     1 NBLADE
      COMMON/ZZZ4/UMACH,OMEGA,ALFA,ABETA
      COMMON/ZZZ5/XPYCTR,YPYCTR,ZPYCTR,RXPYL,RYPYL,RZPYL
      COMMON/ZZZ6/XNOSE,XBD1,XBD2,XTAIL
      COMMON/ZZZ7/YNOSE,YBD1,YBD2,YTAIL
      COMMON/ZZZ8/ZNOSE,ZBD1,ZBD2,ZTAIL
      COMMON/ZZZ9/RYBD1,RZBD1,RYBD2,RZBD2
      COMMON/ZZZ10/RSHAFT,LSHAFT,RSHANK,LSHANK
      COMMON/ZZZ11/XHUBCR,YHUBCR,ZHUBCR,RXHUB,RYHUB,RZHUB
      COMMON/ZZZ12/RROTOR,BCHORD,TAUBL,ALFAB
      COMMON/ZZZ13/THET75,THET1C,THET1S,CONING,AZIMUTH
      COMMON/ZZZ14/KBLADE,TANLEB,TANTEB,XBLE,XBTE,KROTORS(34)
      COMMON/ZZZ15/VSPAN,XLEZV,XTEZV,TANLEV,TANTEV,TAU,ZVTAIL
      COMMON/ZZZ16/NWAKPY,NWAKHB,NWAKSK,NWAKBL
      COMMON/ZZZ17/WAKLPY,WAKLHB,WAKLSK,WAKLBL
      COMMON/ZZZ18/WANGPY,WANGHB,WANGSK,WANGBL
      COMMON/ZZZ19/KPRINT(10),NREAD,NWRITE,KREAD
      COMMON/ZZZ20/PI
      COMMON/ZZZ21/KPY1,KPY2
      COMMON/ZZZ22/KNSELE,KNSSHP,KNSTYP
      COMMON/ZZZ23/KBDELE,KBDSHP,KBDTYP
      COMMON/ZZZ24/KTNELE,KTNSHP,KTNTYP
      COMMON/ZZZ25/KPYELE,KPYSHP,KPYTYP
      COMMON/ZZZ26/KVTELE,KVTSHP,KVTTYP
      COMMON/ZZZ27/KSHELE,KSHSHP,KSHTYP
      COMMON/ZZZ28/KHBELE,KHBSHP,KHBTYP
      COMMON/ZZZ29/KSKELE,KSKSHP,KSKTYP
      COMMON/ZZZ30/KBLELE,KBLSHP,KBLTYP
      COMMON/ZZZ31/NSTAG,NVORT,NSPIRAL,SPIRAL
      INTEGER PP,PM,MP,MM
C
      DOTPRO(X1,Y1,Z1,X2,Y2,Z2)=X1*X2+Y1*Y2+Z1*Z2
      XPROX(DX,DY,DZ,EX,EY,EZ)=DY*EZ-DZ*EY
      XPROY(DX,DY,DZ,EX,EY,EZ)=DZ*EX-DX*EZ
      XPROZ(DX,DY,DZ,EX,EY,EZ)=DX*EY-DY*EX
C
      BETA=SQRT(1.-UMACH*UMACH)
      MULT=1
      MULTZ=1
      IF(KSYMMZ.NE.0) MULTZ=2
      IF(KSYMMY.NE.0) MULT=2
      CLIFT=0.0
      CDRAG=0.0
      CM=0.0
      DO 100 J=1,NELEM
      PP=NODE(1,J)
      PM=NODE(2,J)
      MP=NODE(3,J)
      MM=NODE(4,J)
      DO 200 K=1,3
      YPP=XK(K,PP)
      YPM=XK(K,PM)
```

```
      YMP=XK(K,MP)
      YMM=XK(K,MM)
      A1(K)=(YPP+YPM-YMP-YMM)/4.
      A2(K)=(YPP-YPM+YMP-YMM)/4.
      PC(K)=(YPP+YPM+YMP+YMM)/4.
  200 CONTINUE
      A1(1)=A1(1)*BETA
      A2(1)=A2(1)*BETA
      PC(1)=PC(1)*BETA
C
      A1XA2X=XPROX(A1(1),A1(2),A1(3),A2(1),A2(2),A2(3))
      A1XA2Y=XPROY(A1(1),A1(2),A1(3),A2(1),A2(2),A2(3))
      A1XA2Z=XPROZ(A1(1),A1(2),A1(3),A2(1),A2(2),A2(3))
C
      DELL=A1XA2Z
      CLIFT=CLIFT-4.*CP(J)*DELL*MULT*MULTZ
C
      DELD=A1XA2X
      CDRAG=CDRAG-4.*CP(J)*DELD*MULT*MULTZ
C
  100 CONTINUE
C
      AREA=1.
C
      CLIFT=CLIFT/AREA
      CDRAG=CDRAG/AREA
C
      WRITE(NWRITE,300)CLIFT
  300 FORMAT(//10X,*LIFT COEFFICIENT =*,E12.6)
      WRITE(NWRITE,301)CDRAG
  301 FORMAT(//10X,*DRAG (INDUCED) COEFFICIENT =*,E12.6)
      RETURN
      END
```